CHAPTER 6

WARM AIR SYSTEMS

Section I. DESCRIPTION OF SYSTEMS

6-1. Warm air furnaces.

The primary function of a warm air furnace is to burn fuel efficiently and to transfer the heat generated to the circulating air of a warm air heating system. Most furnaces consist of a combustion chamber (primary heating surface). The furnace may be cast iron, steel, or a combination of the two. The heat transfer per unit area of heating surface is essentially the same for cast iron and steel where both are operated at the same temperature difference. With either cast iron or steel, thicker material yields longer life without materially affecting heat transfer. The furnace may be fired with any of the common fuels and may be of the gravity or forced air type. Gravity warm air furnaces depend upon convection currents to obtain the head required to produce the airflow; forced air furnaces produce the necessary airflow with fans or blowers and are usually equipped with air filters.

6-2. Gravity warm air heating systems.

Operation of gravity warm air heating systems is dependent upon the difference in density (weight) of warm and cold air. Warm air is less dense (lighter) than cooler air and will rise if cooler air is available to displace it. Satisfactory operation of a gravity warm air heating system depends upon three interrelated factors: size and “pull” of the air ducts; building heat loss and; the heat available from the furnace.

a. Ducted gravity systems.

(1) In a ducted gravity system (figure 6-1), warm air is conveyed from the furnace bonnet (top section of the furnace casing), through metal ducts, to the spaces to be heated. Vertical ducts (stacks) connect with registers usually installed in room baseboards, floors, or sidewalls just above the baseboards. Stacks are generally located within inside partitions to prevent chilling of the supply air and consequent reduction in head; cooled air return registers may be located in either cold or warm walls, but cold walls are preferred (unless a long, high-friction-loss duct is required). Gravity warm air systems often have only one or two centrally located return registers, all on the first floor. Upstream of the furnace casing, return ducts usually join a single large duct which enters the casing near the floor or furnace foundation. This connection is made below all parts of the furnace which radiate enough heat to cause a countercurrent of warm air, because such a current opposes the flow of cooled air into the furnace.

(2) The most common source of trouble in gravity systems is insufficient duct area, usually in the cold air (return) duct. The total cross-sectional area of the cold air duct(s) must be at least equal to the total cross-sectional area of all warm air (supply) ducts. If it is necessary to supply additional heat to a space at the end of a long duct run, this can be accomplished by throttling the balancing dampers in other supply ducts to favor the deficient area or installing a booster fan in the deficient duct to force the air stream.

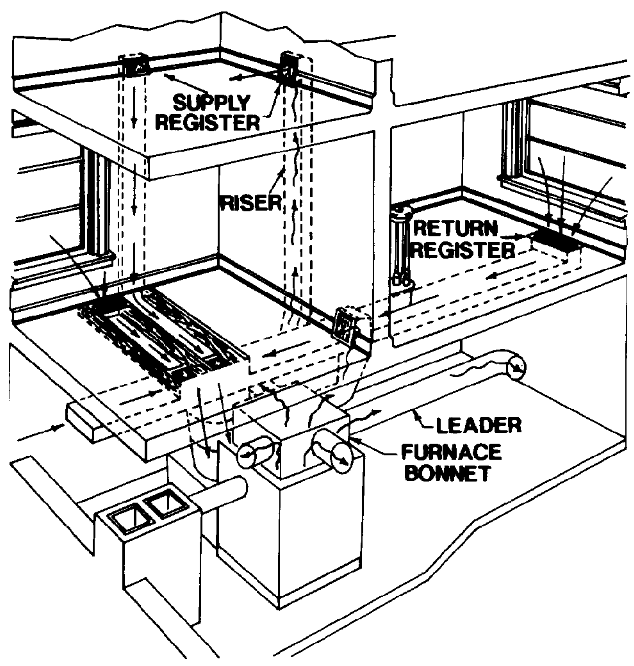


Figure 6–1. Simple gravity warm air heating system.

b. Ductless gravity systems. Ductless gravity furnaces are often installed on floor level; they are simply oversized jacketed space heaters. The most common difficulty experienced with this type of furnace is a return air opening (at the floor) of insufficient area. The return air opening should be made on two or three sides wherever possible. Insulation should be provided above the furnace to avoid possible fire hazards.

6-3. Forced warm air heating systems.

The principal of operation of forced air heating systems differs from that of gravity heating systems in that a fan or blower is included in the former to insure and regulate air movement. Due to the assistance of the fan, duct pitch can be disregarded allowing the most convenient duct runs to be installed. Figure 6-2 shows a typical forced air heating system. In addition to the prime movers (fans), the components of a forced air heating distribution system include supply and return ducts, registers, dampers, and insulation.

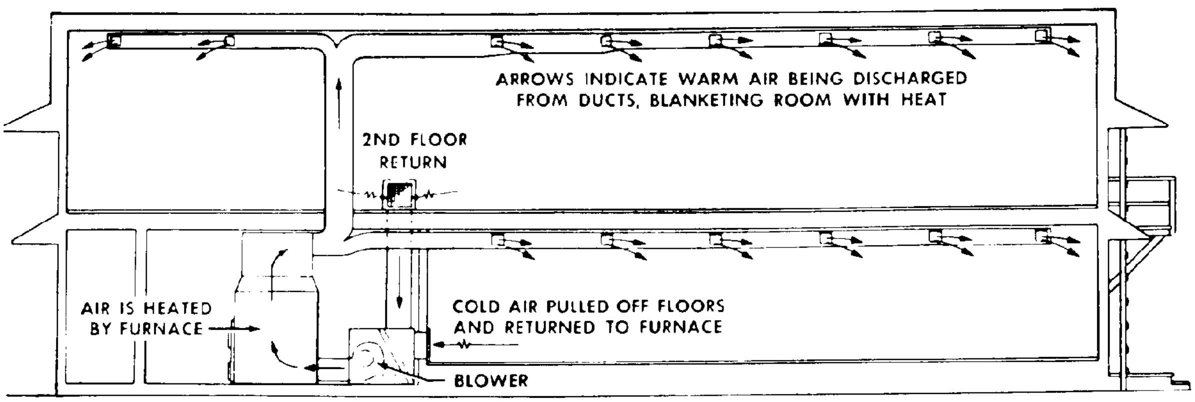


Figure 6-2. Forced warm air heating system.

a. Outside wall delivery system. In this system, supply grilles are located along the outside (perimeter) walls, near the sources of greatest heat loss. These supply grilles (or registers) are designed to blanket the perimeter areas and mix with the cold air from infiltration points thereby reducing or eliminating discomfort due to drafts.

b. Central fan delivery system. This system (figure 6-3) sometimes performs both heating and ventilation functions in large buildings. The air heaters in this system are heat exchangers consisting of pipe coils, finned tubes, or cast iron sections connected into stacks or units by nipples. The intermediate heat carrier is either hot water or steam (from boilers, convertors, etc.) circuited through the heating elements of the heat exchanger. A fan blows (or draws) air through the air heater and supplies it to the spaces to be heated through the distribution ductwork. Because the amount of air required for heating purposes usually exceeds that required for ventilation, economy of operation is improved by recirculating a portion of the heated air. A common central fan delivery system includes the following:

(1) *Outside air inlet duct.* This duct is fitted with a damper to control the influx of outside air to the heated area. The damper may be modulated or fixed in position.

(2) *Air filter.* An air filter is located in the inlet air duct, just upstream of the air heater.

(3) *Return air damper.* A return air damper, installed upstream of the air filter, permits a regulated recirculation of heated air into the outside air inlet duct. The combined operation of this damper and the outside air damper (which controls the influx of cold air) provides for tempering the outside air introduced into the system.

(4) *Air heater.* The air heater (a heat exchanger heated by steam or hot water) is located in the mixed air duct, downstream of the air filter.

(5) *Fan.* A motor operated fan, located after the air heater, draws the tempered air through the heat and discharges it to a trunk line. “Blow-through” arrangements locate the fan upstream of the air heater.

(6) *Trunk line.* This is a main duct with individual branches taken off at intervals to carry the tempered air to the required spaces. Dampers at either the branch take-off points or the branch outlets provide balanced air distribution. The duct may be made from galvanized steel sheets; both aluminum and non-metallic ducts also are used extensively.

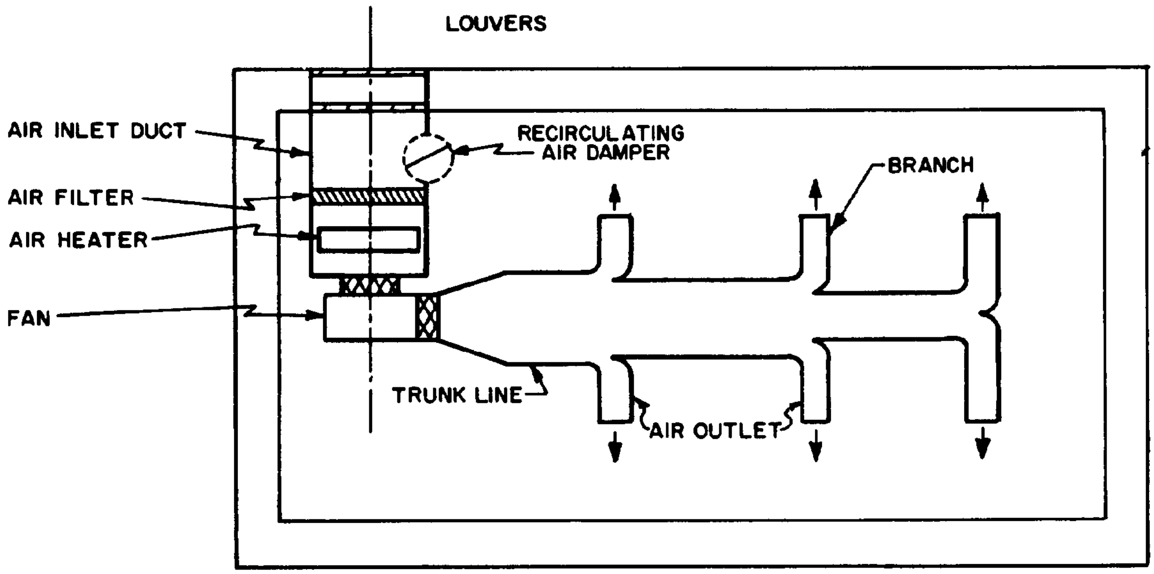


Figure 6-3. Central fan heating system.

c. Perimeter delivery systems. Perimeter systems usually employ the outside wall delivery system. Air returns to the furnace through centrally located, high sidewall or ceiling grilles. Return ducts may be located in attics or other unheated spaces. Return air may be taken from crawl spaces and basements, but never from a confined space in which the furnace is located. In perimeter systems, a downflow furnace is normally used. In this type furnace, cold air enters the unit from above and is discharged as warm air from the bottom or lower part of the furnace casing. Figure 6-4 illustrates one type of perimeter system called a loop system.

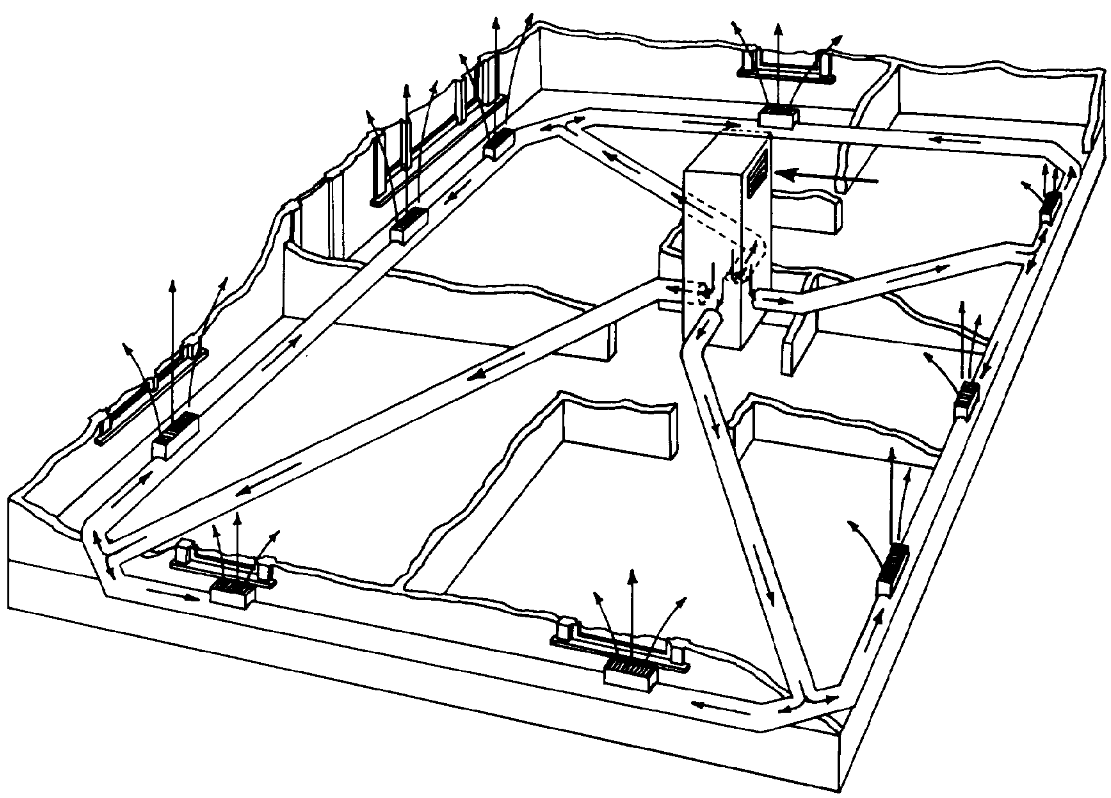


Figure 6-4. Perimeter loop delivery system.

d. Inside wall delivery system. Supply grilles are located on an inside (warm) wall, either high or near the floor. Return registers are located near the greatest exterior exposure. High wall registers deliver the air either horizontally or slightly downward, so that it does not strike the ceiling or wall. For best results, multi-directional grilles are used, distributing the airflow uniformly. To reduce the discharge velocity, grilles are used with an area larger than that of the connecting duct. Location of the warm air return grille depends on the location of the supply grilles.

e. Ceiling delivery system. This system employs ceiling diffusers to deliver the warm air to the desired spaces. With annular ceiling diffusers, the airstream is spread a full 360 degrees and the rate of diffusion is high; however, the throw is rather short, requiring (or in some cases allowing) high air discharge velocities.

6-4. Ratings of warm air furnaces.

Furnace rating is usually determined by BTU delivery per hour at the bonnet. Standard ratings for different manufacturer's furnaces can be obtained from the various trade associations, depending upon the type of fuel fired by the furnace.

Section II. COAL FIRED WARM AIR FURNACES

6-5. Steel furnaces.

Steel furnaces (figure 6-5) are constructed of heavy gauge steel, riveted and caulked or welded at the joints to make them air-tight. The fire-feed, ashpit, and draft doors, usually made of cast iron, are located at the front of the furnace. In smaller sizes, steel furnaces usually have a single radiator (secondary heating surface) attached to the rear of the combustion chamber. In large sizes, two additional radiators may be installed on the sides of the furnace. All radiators must have a cleanout opening. Steel furnaces are, in general, more common than cast iron furnaces on Army installations.

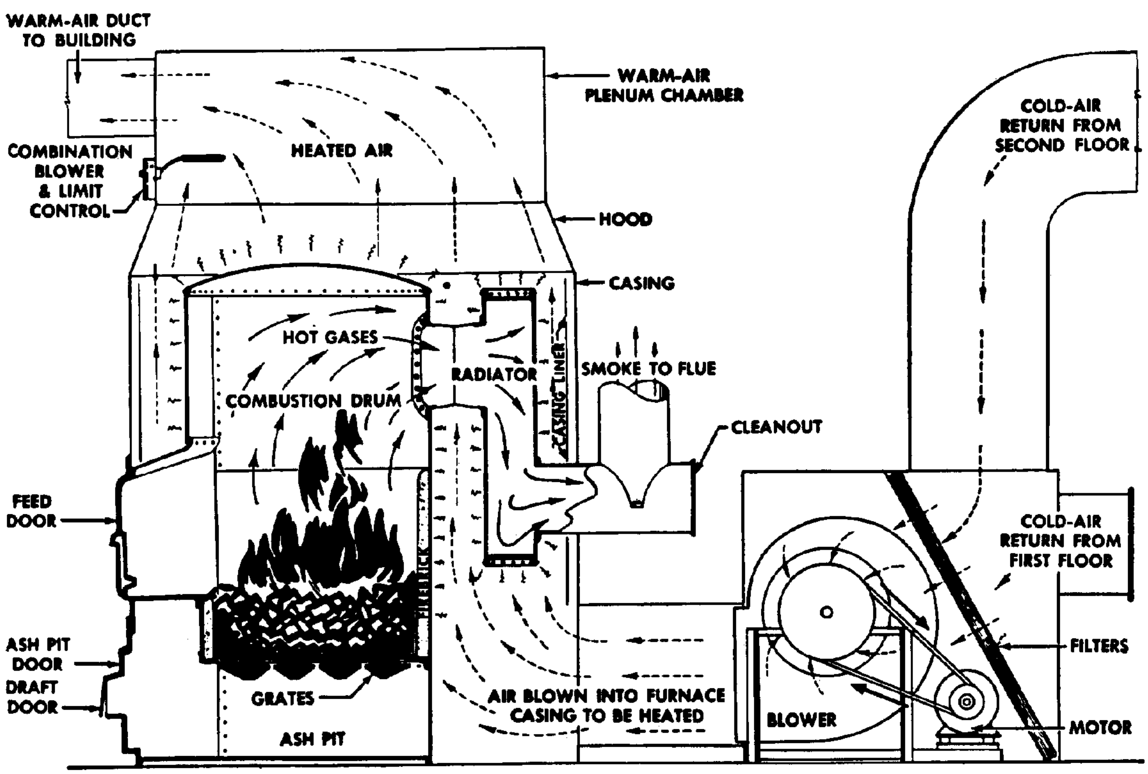


Figure 6-5. Coal fired steel forced warm air furnace.

6-6. Cast iron furnaces.

Cast iron furnaces are constructed in sections which are made airtight by the use of liberal amounts of furnace cement. Use cement supplied by the furnace manufacturer in a fashion consistent with the manufacturer's recommendations. The radiator (secondary heating surface) is usually located on top of the combustion chamber dome. Both steel and cast iron coal fired furnaces must be installed on a solid masonry base. Do not install on a base made with wood or other combustible material.

6-7. Ratings and sizes.

Ratings are determined by BTU per hour (BTUH) delivery at the bonnet. Standard code ratings are used in sizing coal fired furnaces, in accordance with the following formulas:

a. Furnaces with 294,000 BTUH or less output.
BTUH output at the furnace bonnet = [area of grate in square feet] x [7.5 pounds of coal] x [BTU content per pound of coal] x [0.65 (efficiency)]

b. Furnaces with more than 294,000 BTUH output.
BTUH output at the furnace bonnet = [area of grate in square feet] x [10.0 pounds of coal] x [BTU content per pound of coal] x [0.70 (efficiency)]

6-8. Smokepipe.

The smokestack from furnace to chimney must be 18 gauge or heavier steel, and at least as large (in cross-sectional area) as the furnace collar. Avoid the use of elbows wherever possible. Install the check draft used with bituminous or anthracite coal with hinges on the top sides of the smokepipe for easy (chain) operation by the damper motor. For buckwheat coal, a checkdraft is generally omitted, but a balanced atmospheric type damper should be installed to regulate chimney draft. (See figures 6-6 and 6-7.)

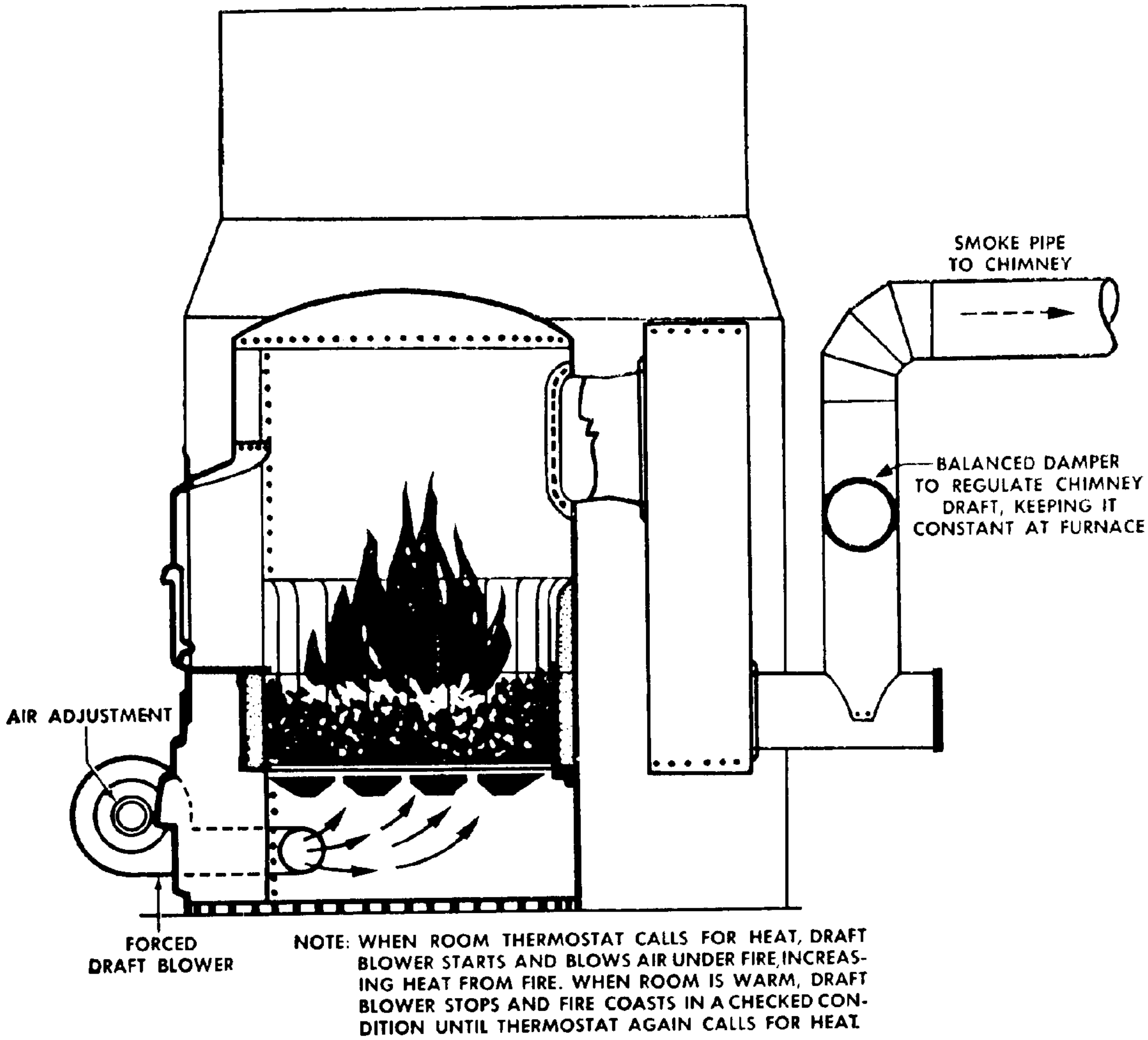


Figure 6–6. Draft control for anthracite coal furnace.

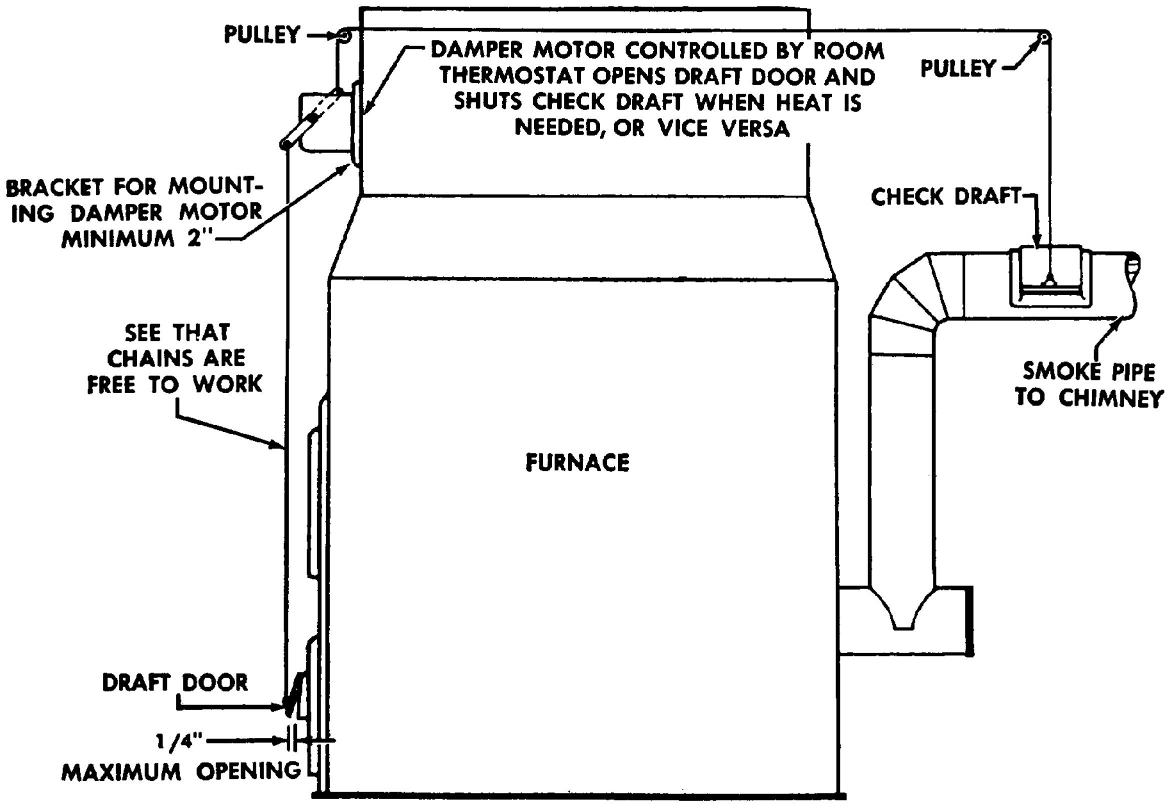


Figure 6-7. Draft control for bituminous coal furnace.

6-9. Motor damper.

Install the motor damper such that it has no direct contact with the furnace or bonnet. Motors installed on the bonnet or furnace are should be mounted on a bracket which extends out to allow for air passage, or are mounted on insulators to prevent excessive heating.

6-10. Chimney.

The importance of the chimney in the proper combustion of coal cannot be overemphasized. Every pound of coal requires from 150 to 250 cubic feet of air for proper combustion; sufficient draft must be maintained through the fuel bed to supply this amount of air. A blocked chimney or chimney downdraft can cause inadequate draft and therefore, incomplete combustion and create carbon monoxide. A chimney must have sufficient area and height, and must be tight from bottom to top. The most efficient chimney shape is round; however, because rectangular chimneys are commonly used, particular attention must be given to them. Rectangular chimneys must be carefully checked, from the standpoint of both area and dimensions.

a. Area. A chimney must have a cross-sectional area greater than or equal to that of the smoke-pipe outlet from the furnace. The smaller dimension of of a rectangular flue must be at least two-thirds of the smokepipe diameter. Chimney cross-sectional area must be increased 4 percent for each 1,000 feet of elevation above sea level.

b. Height. Follow manufacturer's recommendations on chimney height at all times. Height of the chimney may be 85 percent of the recommended height without requiring compensation; however, for each 10-percent decrease below recommended height, add 6 percent to the grate area to get the same furnace heat output (BTUH). All chimneys must extend at least 2 feet above the peak of the roof and in no cases should chimney height be less than 15 feet, even for small furnaces.

Section III. OIL FIRED WARM AIR FURNACES

6-11. General description.

Oil fired furnaces may be designed and built exclusively for use with fuel oil, or oil conversion burners may be installed in furnaces originally burning coal. Standard design and installation practices for fire prevention are detailed in the applicable codes, technical manuals, and manufacturer's literature.

6-12. Oil furnaces.

With oil furnaces, maximum efficiency (beyond that possible with oil conversion burners) is the result of proper sizing of the combustion chamber and the firepot volumes, longer heat travel, and very large heating surfaces. Oil furnaces are usually of the blowthru type, with an air space pressure greater than the combustion chamber pressure. Compact fan-furnace-burner units may be installed in basements, attics, or other locations with limited space. Figure 6-8 illustrates a typical oil fired furnace.

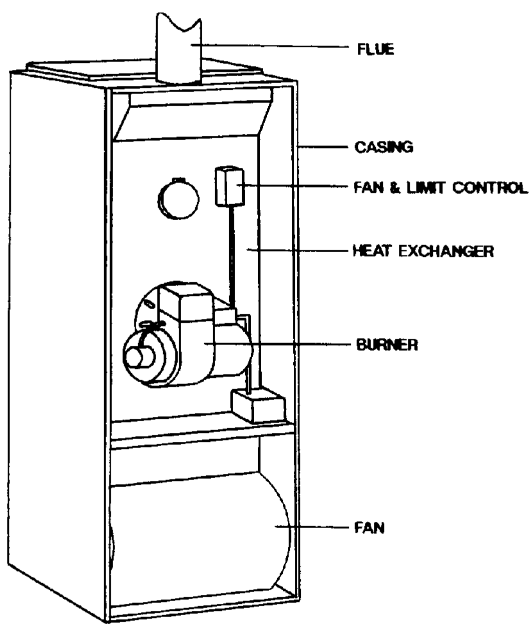


Figure 6-8. Typical oil fired furnace.

6-13 Oil conversion furnace.

Coal furnaces may be modified for oil firing capabilities by installing oil conversion burners in existing coal furnaces.

a. Firepot. The firepot may be either round or square. Normally, a 24-gauge sheet metal drum is set on a brick floor inside the furnace. The sheet metal acts as a retainer for the firepot wall. Bricks are cemented with special mortar, made for the particular brick used. The space between the firepot wall and the furnace body is not filled. Heat is allowed to flow behind the refractory pot. In gravity warm air installations, a radiation shield is installed between furnace body and casing to prevent radiant heat from retarding cold air circulation. Refer to figure 6-9 for typical firepot construction.

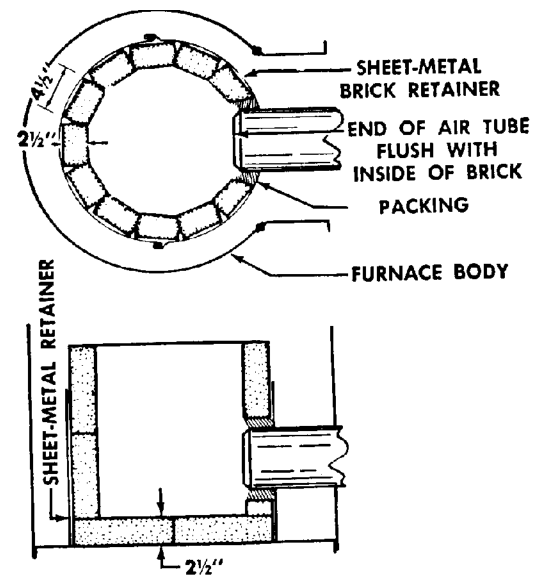


Figure 6-9. Typical firepot construction.

b. Oil conversion burner installation.

(1) *Installing burner.*

(a) Set burner with end of blast tube flush with the inside wall of the firepot. (See Table 6-1 and firepot diagrams, figures 6-10 and 6-11.)

Table 6-1. Recommended Firebox Sizes

Firing Rate (gph)	Round Firepot Size (in) A	Round Firepot Size (in) B	Round Firepot Size (in) C	Rectangular—Firepot Spray Angle (degrees)	Rectangular—Firepot Size (in) A	Rectangular—Firepot Size (in) B	Rectangular—Firepot Size (in) C	Rectangular—Firepot Size (in) D
0.80	10.0	16.0	6.0					
1.00	11.0	18.0	6.0	80	9.5	9.0	6.0	14.0
1.35	13.0	18.0	6.0	80	12.0	10.0	6.0	14.0
1.50	14.0	18.0	6.0	80	12.5	11.0	6.0	18.0
1.75	15.0	18.0	6.0	80	14.0	12.0	6.0	18.0
2.00	16.0	18.0	6.0	60	15.0	13.0	6.0	18.0
2.50	18.5	18.0	6.0	60	17.0	15.0	6.0	18.0
3.00	20.5	18.0	7.0	60	19.0	16.0	7.0	18.0
3.50	22.5	18.0	7.0	60	22.0	17.0	7.0	18.0
4.00	24.0	18.0	7.0	60	26.0	19.0	7.0	18.0
4.50	26.0	18.0	8.0	60	29.0	20.0	8.0	18.0
5.00	27.5	18.0	8.0	60	32.0	21.0	8.0	18.0
5.50	29.5	18.0	8.0	60	36.0	22.0	8.0	18.0
6.00	31.0	18.0	8.0	60	40.0	23.0	8.0	18.0

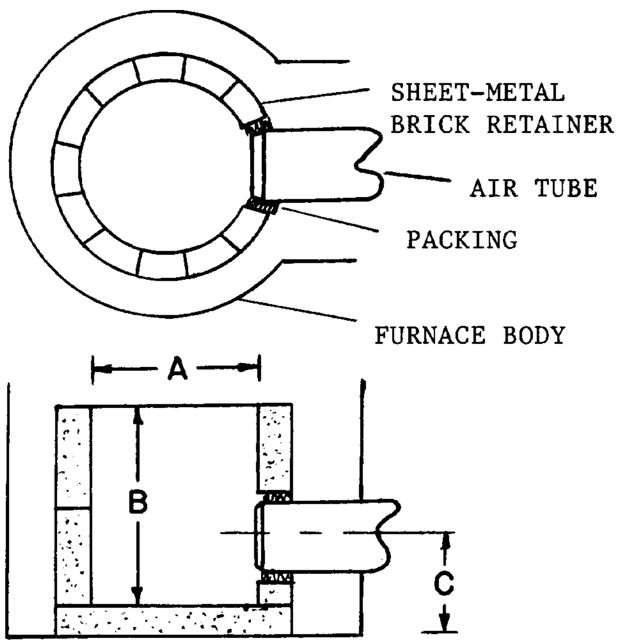


Figure 6-10. Round firepot.

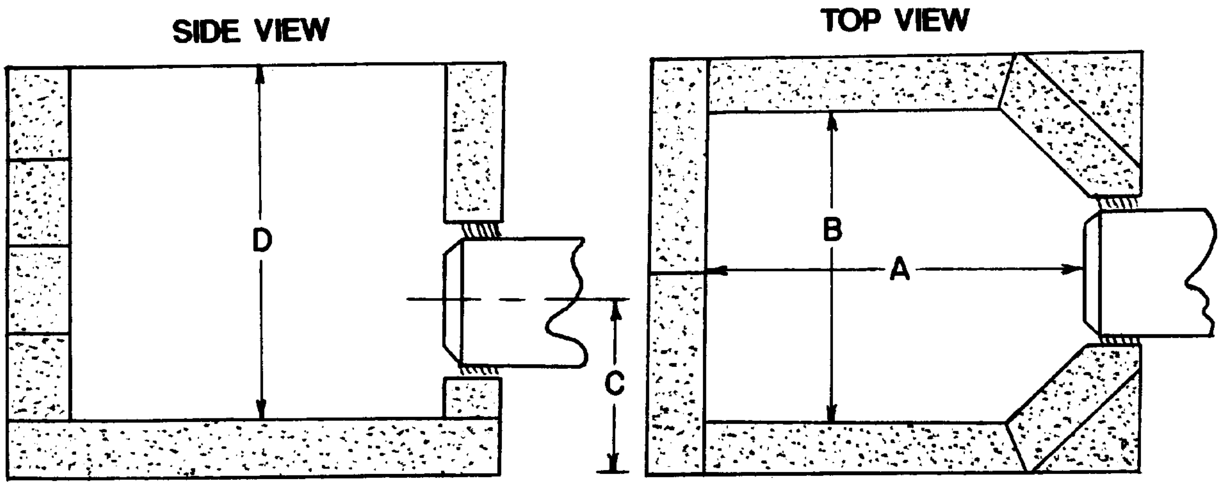


Figure 6-11. Square firepot.

(b) Pack around the blast tube to close the gap between the refractory and the burner blast tube. This prevents the flame from licking back on the blast tube and eventually burning it off. Leave a groove at the bottom of the packing so that oil dripping from the blast tube can drain into the firepot.

(c) Secure the burner to the floor with lag screws unless some other provision has been made in the furnace unit for locking the burner in place.

(2) *Installing constant ignition controls.*

(a) Select the appropriate wiring diagram from figures 6-12 and 6-13, depending on the air distribution system type (gravity or forced air). These diagrams are for constant ignition burners.

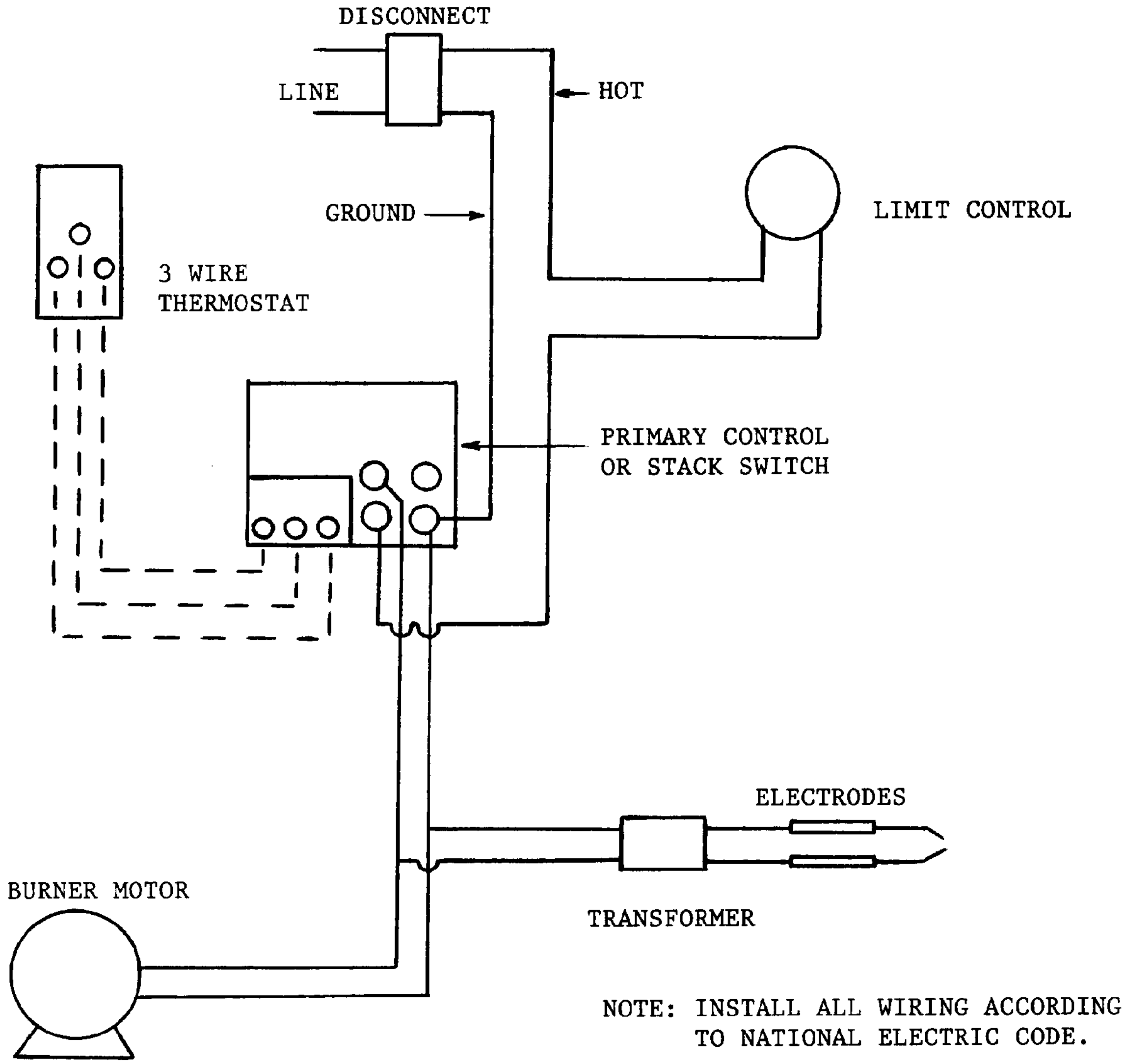


Figure 6-12. Wiring diagram, gravity furnace, constant ignition.

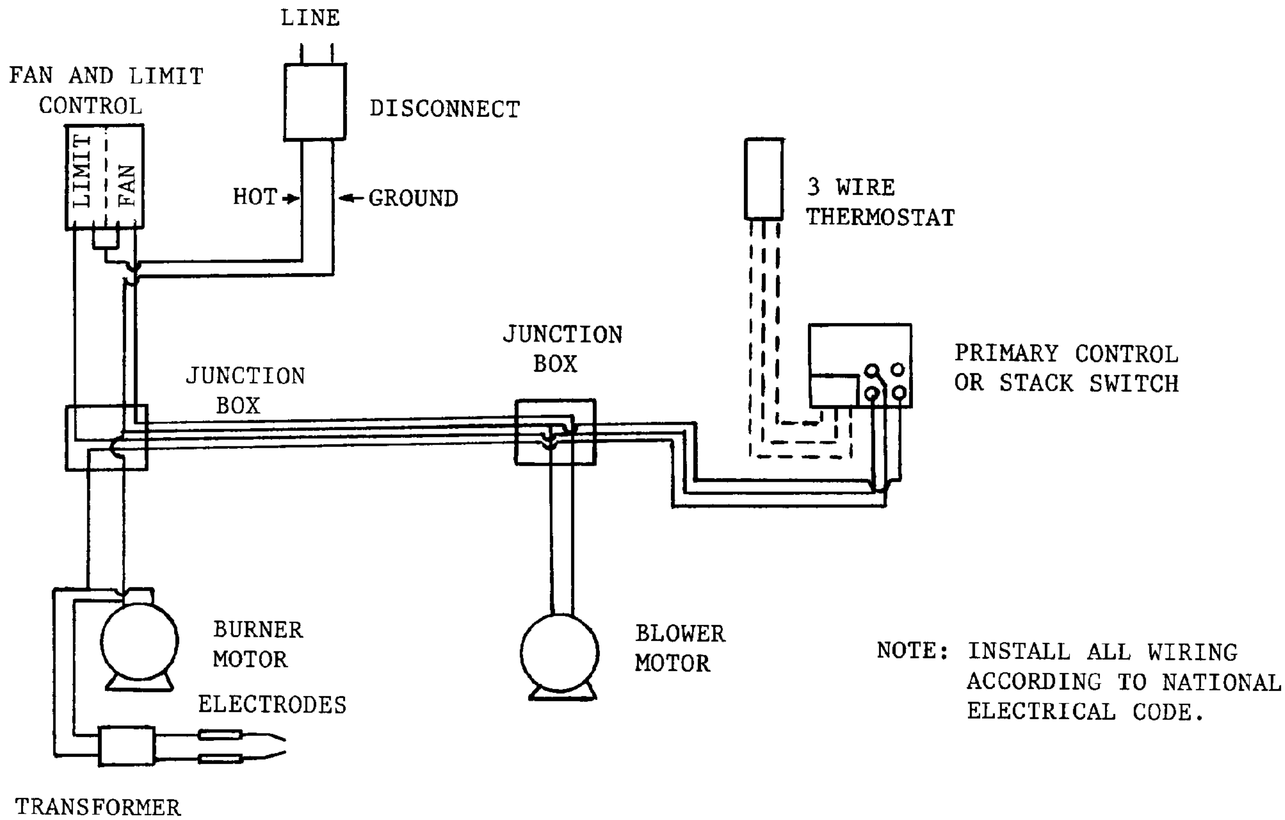


Figure 6-13. Wiring diagram, forced air furnace, constant ignition.

(b) Check the polarity of the wiring circuit carefully to ensure that "hot" and ground connections are as shown in the appropriate wiring diagram.

(c) Note that the burner motor and ignition transformer are wired in parallel; that is, one wire from each is connected to the "hot" line and the remaining wire from each is connected to the ground wire. If RF suppression (radio filter) is required, it should be wired in parallel with both the burner motor and ignition transformer.

(3) *Nozzle sizing.* Size the nozzle so that the furnace will provide enough heat to match the calculated heat loss of the building at design conditions. Oversizing results in lowered efficiency, frequent burner cycling and temperature fluctuations within the building. In no case should the nozzle ever be sized larger than the input rating of the furnace. Assuming a furnace efficiency of 70 percent, the nozzle can be sized as follows:

Nozzle Rate, GPH=(BTUH Heat Loss)/(138,200 x .70)

(4) *Nozzle selection.* Choose nozzles used in small units carefully. If a new unit using a new nozzle does not produce a perfect fire, try several other nozzles with the same markings. Trouble can occur even with new nozzles despite care used in its selection. For this reason, keep several spare nozzles in stock.

Section IV. GAS FIRED WARM AIR FURNACES

6-14. General.

Gas fired warm air furnaces may be of the central type with the blower mounted on the same level as the combustion chamber (figure 6-14), the elevated or "Hi-Boy" type with the combustion chamber above the blower (figure 6-15), or they may be of the duct or horizontal radiator type (figure 6-16).

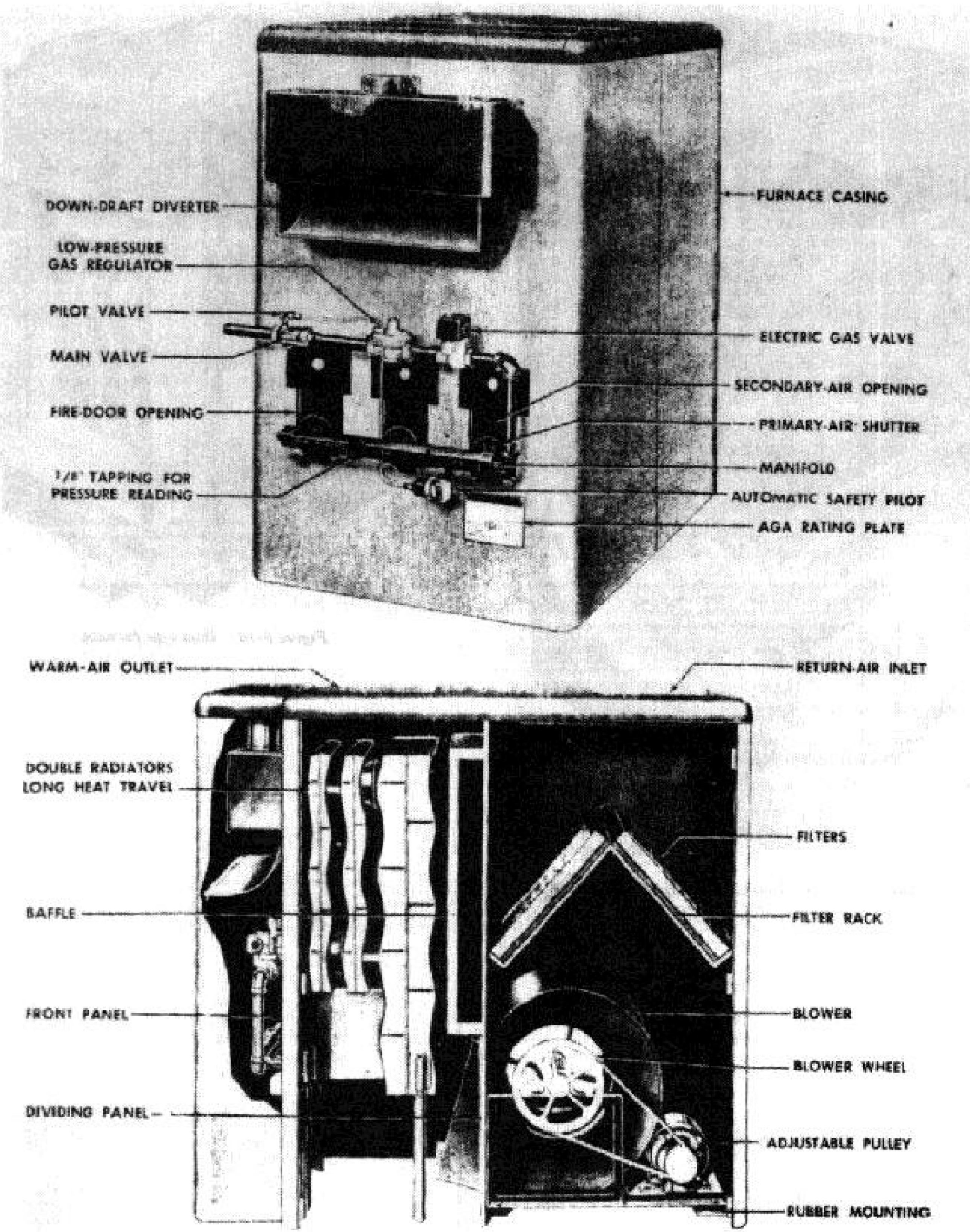


Figure 6-14. Gas fired central furnace.

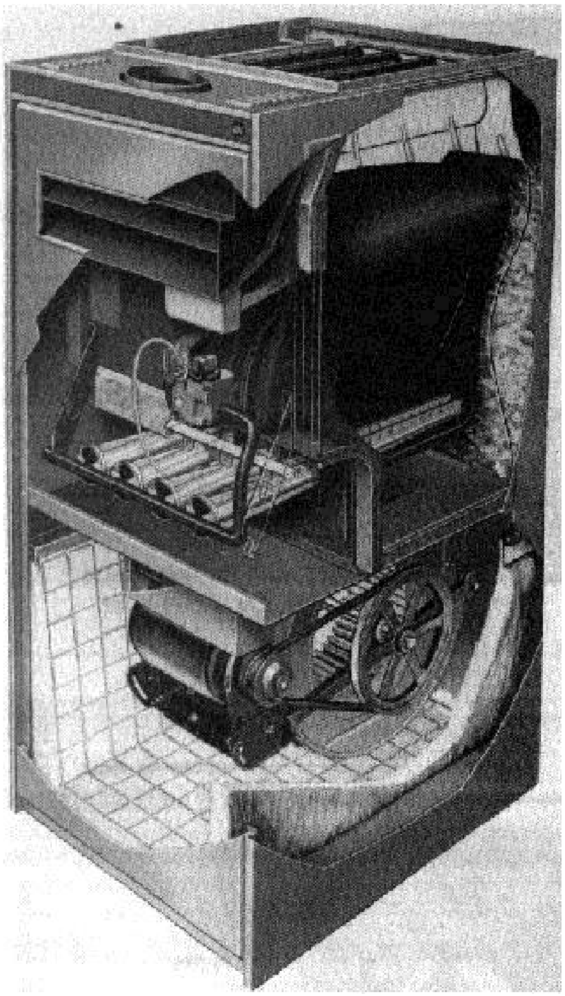


Figure 6-15. Gas fired elevated upflow furnace.

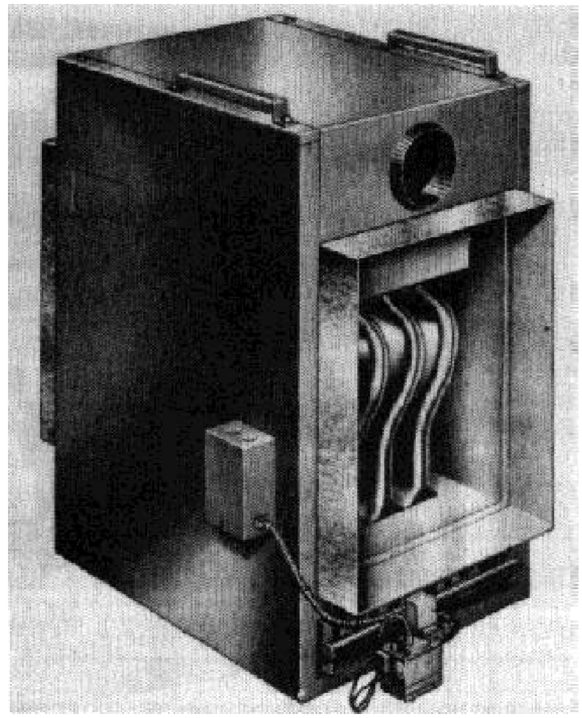


Figure 6-16. Duct type furnace.

6-15. Construction.

Gas fired warm air furnaces are made of cast iron or steel. They are usually constructed with one or more radiators or special radiating surfaces to obtain maximum efficiency. They may be used in either gravity or forced air installations.

6-16. Furnace rating.

Always set the gas input rate consistent with the manufacturer's input rating; never exceed this rating. Heat delivery at the bonnet drops approximately 5 percent for each 1000 feet of elevation above sea level. Thus, if a furnace has a rating of 100,000 BTUH output at sea level, it will deliver only 75,000 BTUH at an elevation of 5000 feet above sea level. Furnaces must be sized consistent with this rule when they are intended for use at higher elevations.

6-17. Central furnaces.

Central furnaces may be supplied with the controls and downdraft diverter exposed, or one or both of these may be enclosed in a single cabinet if appearance is a factor. Likewise, the blower may be installed as a separate item, attached to the furnace by a "blower-boot" located between the furnace and the blower cabinet.

6-18. Vertical furnaces (Hi-Boy type).

This is the predominate type of gas furnace found at Army installations. Operation of the elevated unit or "High-Boy" is identical to that of the central unit.

a. Upflow vertical furnaces. Return air enters the unit through the return air duct located at the bottom or side of the unit and is drawn into and forced through the blower; it is then guided by baffles around and through the heat exchanger and discharged through the top.

b. Down flow vertical furnaces. The return air inlet is located at the top or upper side of the unit. Air is directed through the blower and heat exchanger and is discharged at the bottom of the unit. These type units are typically used in underfloor air distribution systems. Figure 6-17 shows a typical downflow furnace.

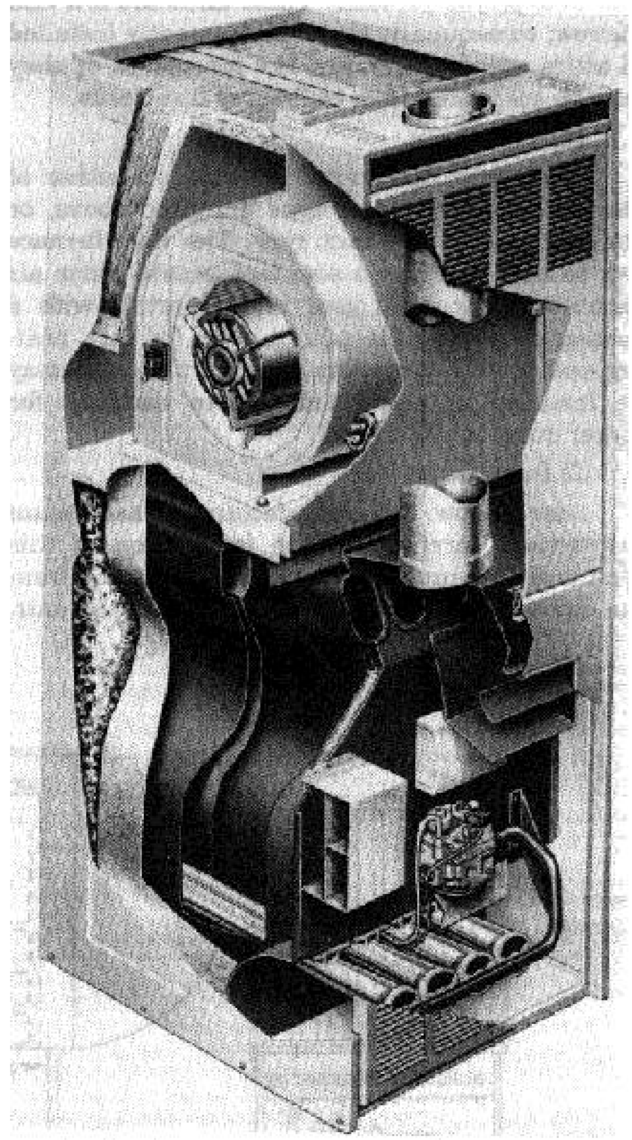


Figure 6-17. Gas fired elevated downflow furnace.

6-19. Horizontal furnaces.

In a horizontal furnace, the blower, filters, and heat exchangers are aligned horizontally with respect to each other.

a. Low profile furnaces. These units are low and narrow; consequently they are frequently installed in attics, crawl spaces, and low basements, or they may be suspended from ceilings or floor joists.

b. Duct furnaces.

(1) *General.* Horizontal furnaces are either of the low profile compact type described above, or they may be of the duct type. The duct furnace can be used as either a standard central warm air furnace or it can be used in conjunction with a cooling coil, using the same blower for both heating and cooling operations. The duct furnace may be installed in single units or in batteries for larger outputs.

(2) *Installation.*

(a) Follow the manufacturer's installation instructions carefully in the installation of this type unit. Air must always enter the casing from the direction of the baffles located within the unit. Baffles are precisely located by the manufacturer to properly distribute air over the heating elements; do not attempt to adjust them. Failure to properly install these baffles usually results in failure of the unit after one or two seasons of operation.

(b) Exercise care to install the unit so that air flow is in the direction recommended by the manufacturer. Failure to do this may result in a burned out unit and/or unsatisfactory operation.

(c) If the blower and blower casing are not supplied by the furnace manufacturer, they must be installed with the blower outlet on an even plane with the radiators or combustion section of the unit, so that the air will pass through the unit in a horizontal stream (figure 6-18). Carefully monitor the gas input to avoid overfiring, which will result in damage to the radiators or combustion chamber. The control assembly is the same as that used on standard gas furnaces.

(d) In multiple furnace arrangements, each furnace must have its own downdraft diverter; vents should be joined by Y-fittings, never by T-fittings.

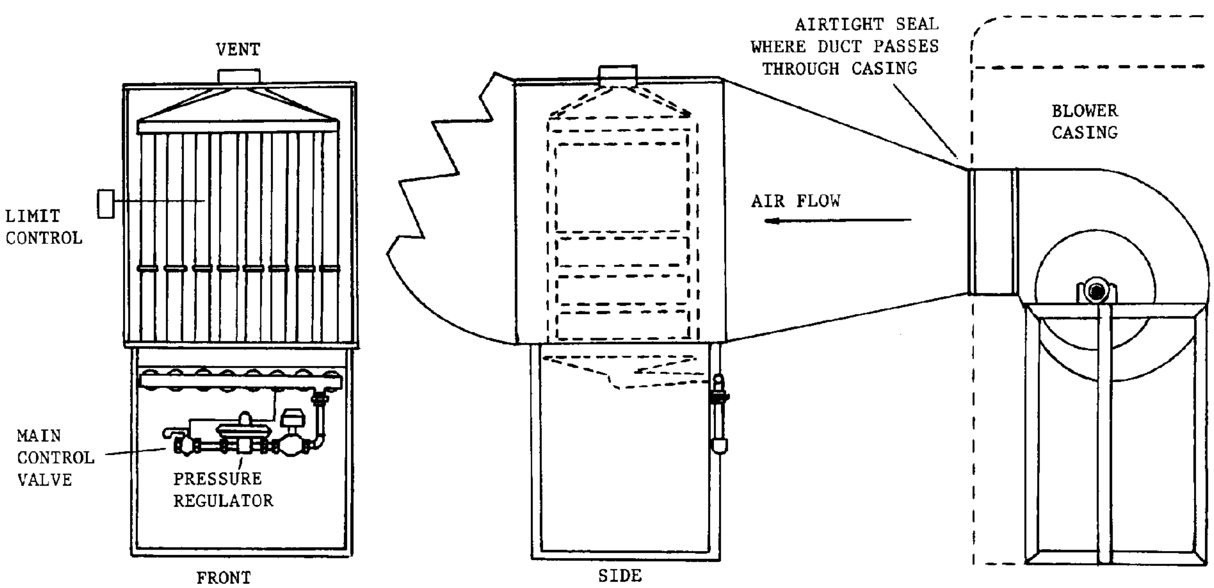


Figure 6-18. Installation of a typical duct furnace.

(3) *Air delivery.* The maximum and minimum air deliveries for which these furnaces are designed are shown on the nameplate or in the manufacturer's literature. In no case should air be delivered above or below those ratings. Too low an air flow rate will result in excessive temperatures, while too high a delivery may result in condensation within the unit. Both conditions will shorten the life of the unit.

(4) *Use with refrigeration system.* Never install a duct furnace downstream from a refrigeration coil, because the cold air will cool down the heating elements, causing reverse circulation of moisture-laden air down the vent through the inside of the heating element. This will result in rust scale,

shortening the life of the unit as well as closing flue passages and impairing combustion. It is also unsatisfactory to install a duct furnace upstream from the cooling coil, as the cooling coil may be damaged or the refrigerant decomposed during the heating season. When both heating and cooling coils are used in the same system, install the coils in parallel (figure 6-19) using a damper downstream of the furnace to change over from the heating to the cooling cycle. If more air is required for ventilation than is permitted by the manufacturer, the additional air must bypass the furnace through a duct around it. This bypass must be equipped with a volume control damper, properly adjusted to maintain the appropriate air flow through the furnace. Occasionally, bypass ducts are used to obtain larger volumes of air for summer ventilation than for winter heating. In such cases, the installation must be equipped with interlocking control to prevent the furnace from operating unless dampers are set for proper air delivery through the furnace.

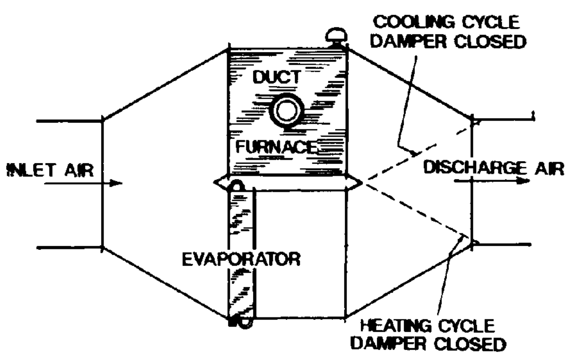


Figure 6-19. Damper arrangement for duct furnace and cooling coil.

6-20. Gas conversion furnaces.

In certain instances, coal furnaces may be modified for gas burning capability through the installation of gas conversion burners. Before installing a gas conversion burner in a coal furnace, carefully study the existing heating system to assure that: the furnace and heating system are in good operating condition; the furnace has sufficient capacity to heat the building properly and; the fire-box or combustion chamber must be large enough for the conversion burner. Normally, gas conversion burners are not recommended for warm air furnaces or small boilers because of the cost of operation; it is usually more economical to replace a coal burning furnace with a unit specifically designed for gas fired operation.

a. Gas conversion burner. A leaning refractory type of burner is considered most satisfactory for the average small coal fired furnace because hot gases are directed along and against the radiating surface, which is limited. In this type burner, baffles are supported at one end by a support on the inner side of the burner and at the other end by a retaining ring. Gas combustion occurs below the leaning baffle. Most leaning baffle type burners have a draft door which will open to a predetermined point while the burner is in operation and will close when the gas is shut off. Open the draft doors just enough to admit the proper amount of primary and secondary air (determine the amount of air admitted at this point by the appearance of the gas flame or by the use of a combustion analyzer).

b. Gas conversion burner installation. If the furnace smokepipe outlet is less than 18 inches above the grate level, there is usually insufficient draft for proper operation of the burner. Gas conversion burners operate at low efficiency with high fuel consumption in all types of furnaces which do not have a radiator or secondary heating surface. This type of furnace is unsuitable for efficient operation of a gas conversion burner. Inspect and test for leaks to insures that no products of combustion escape into the heated air delivered to the building.

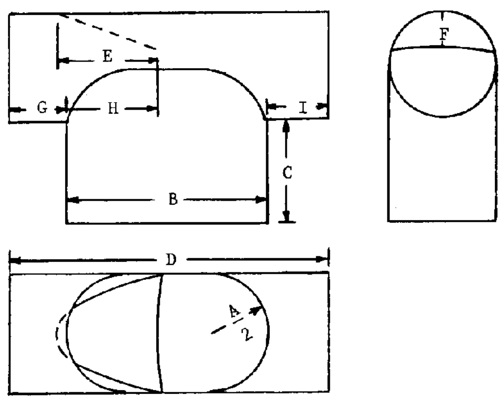
(1) *Burner capacity.* In determining conversion burner size (BTUH input), not more than 70% efficiency should be assumed and frequently the efficiency obtained is less. In addition to the heating load of the building, the BTUH input must be great enough to allow for this low efficiency plus pipe loss and an additional 25 percent for the starting load.

(2) *Controls.* Controls used on gas conversion burners should be of the same type as controls recommended for gas designed furnaces. Never install so-called “homemade burners”; never install a burner in the firing door.

(3) *Flue pipe/vent.* Complete heating plants designed for gas fired furnaces and unit heaters are constructed with a flue outlet of proper construction and proper draft (downdraft diverter). A damper is therefore not required in the vent pipe. Gas conversion burners installed in coal furnaces which have a flue outlet designed for coal burning operation need a damper in the flue pipe to reduce the draft to a proper value. Provide a check damper or similar opening in the flue pipe and an adjustable pipe damper between the check damper and the furnace for “fine-tuning” of the draft.

(4) *Draft hood.* A draft hood may be used in place of the check damper. Even with its use, however, in most cases it is impossible to establish the draft through the furnace accurately by the use of a

draft hood alone. For this reason, the pipe damper is still required. In the absence of a regular canopy or hood type downdraft diverter, a satisfactory type of draft hood can be fabricated as shown in figure 6-20.



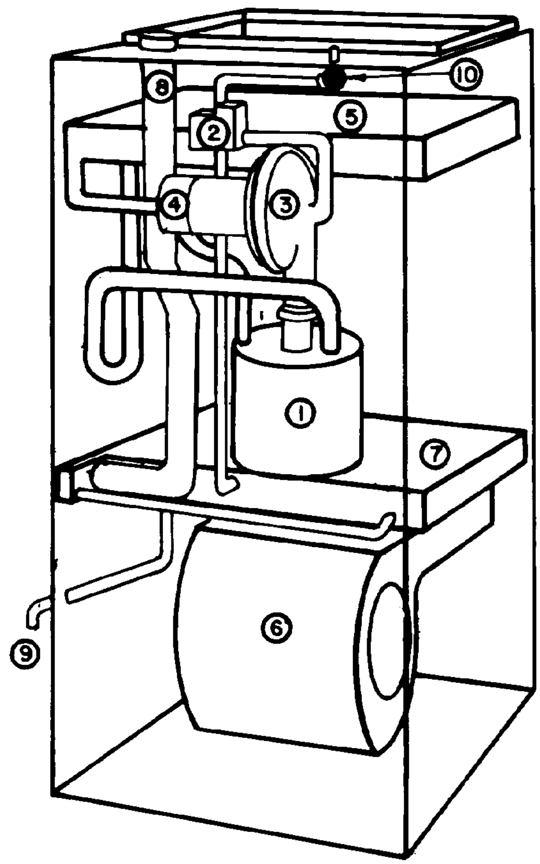
DIMENSIONS (INCHES)

PIPE SIZE	A	B	C	D	E	F	G	H	I
3	3	5.4	3.3	10.0	2.3	1.0	2.2	2.4	2.4
4	4	7.3	3.5	12.0	3.5	1.4	2.3	3.3	2.5
5	5	9.2	3.8	14.1	4.8	1.8	2.4	4.1	2.5
6	6	11.0	4.0	16.3	5.6	2.1	2.6	5.0	2.6
7	7	12.8	4.1	18.0	6.6	2.5	2.6	5.8	2.6
8	8	14.6	4.3	20.0	7.3	2.8	2.6	6.6	2.8
9	9	16.5	4.4	21.9	8.3	3.2	2.6	7.4	2.8
10	10	18.3	4.5	24.0	9.2	3.5	2.8	8.3	2.9
11	11	20.2	4.6	25.9	10.3	3.9	2.8	9.1	2.9
12	12	22.0	4.8	27.8	11.0	4.2	2.8	10.0	3.0

Figure 6-20. Draft hood.

6-21. Fully condensing furnaces.

The term “fully condensing” refers to the fact that the flue gas from these furnaces passes through a heat exchanger coil in the air stream (upstream of the heating section), substantially cooling and condensing the products of combustion. This is essentially a flue gas heat reclaim system packaged within the furnace, yielding a very efficient heating system. Efficiencies of 90 to 95 percent are commonly reported. Instead of discharging flue gas at temperatures greater than 400F, as is common with gas fired furnaces, these units discharge condensate to a suitable drain and low temperature exhaust gas through a plastic vent pipe. Because the condensate contains combustion byproducts, it is mildly acidic. Some condensing furnaces open a water valve at the end of each heating cycle, which flushes the coil and carries away any remaining condensate (figure 6-21). Operating procedures vary depending on the manufacturer, but for the most part, fully condensing furnaces are operated similar to conventional furnaces.



1. HEAT TRANSFER MODULE.
2. NEGATIVE PRESSURE GAS VALVE
3. COMBUSTION AIR BLOWER
4. SOLUTION PUMP
5. HEATING COIL
6. BLOWER.
7. RECUPERATIVE COIL.
8. EXHAUST PIPE
9. CONDENSATE DRAIN
10 WATER VALVE

Figure 6-21. Typical fully condensing furnace.

6-22. Fully condensing furnace maintenance. Disconnect electrical power before servicing. Check the furnace at least once every year, before the heating season begins, to be sure that there is adequate combustion air and that the vent system is working properly. Check the vent pipe to be sure it is not blocked.

a. Combustion air.

(1) Normally the air for combustion and ventilation for a furnace can be obtained from the basement area.

(2) If a furnace is installed in a closet and the closet door is louvered, do not obstruct louvers. Louvers must be open and clear to provide combustion air to the furnace.

(3) If the furnace is installed in a confined space within a building and the air for combustion enters the space through ducts from the outside, be sure to check the entering and outlet (grilled) openings so that they are always clear and clean.

b. Blower motor lubrication. Always relubricate the motor according to the manufacturer's lubrication instructions on each motor. Some blower motors are permanently lubricated and do not require any further oiling.

c. Filters. The filter in the furnace is designed for high velocity heating and cooling applications.

Filters of the washable type may be washed and dried. Spray the filter media with a dust adhesive as per instructions on the adhesive spray container. Filters should be inspected and cleaned every two months or as required.

(1) Remove the filter per manufacturer's instructions.

(2) Use a vacuum cleaner to clean out the blower area and the adjacent area of the return air duct.

(3) Clean, wash and dry the permanent filter, then spray both sides with a dust adhesive as recommended on the adhesive container. Re-install the filter. Be sure the arrow on the filter points in the direction of the air flow.

d. Check heating solution. For those furnaces using a liquid heating solution, check this during the annual inspection. Observe the solution level in the plastic expansion tank. Remove the top door on the front of the furnace and observe the solution level. It should be between the two straps which secure the plastic tank. Refer to the label on the tank. If it is necessary to add solution be-cause of evaporation losses or minute leaks, refer to manufacturer's instructions.

e. Operating difficulties. If the furnace fails to operate, it is possible the safety pressure switch is open. This switch is used on some furnaces to shut down the system if the condensate line or flue is blocked. The combustion blower will continue to run until the blockage in the flue pipe or condensate discharge line is clear. Do not discharge condensate to the outside if there is a possibility of freezing. To avoid blockage in the condensate line, condensate should discharge into an open drain and the tubing should be protected so that it cannot be crushed or flattened out.

6-23. Pulse combustion furnaces.

These furnaces are also "fully condensing" but obtain higher efficiency by means of the pulse combustion principle. These units do not require a pilot burner, main burners, conventional flue or chimney. Initially the combustion takes place in a chamber; then, as combustion products pass through the heat exchanger system into a coil, the latent heat of combustion is extracted, condensing water from the exhaust gas. Electronic spark ignition is used to initiate combustion. A schematic representation and sequence of operation are presented in figure 6-22. Pulsed combustion furnaces have efficiencies as high as 95 percent and, as with the fully-condensing furnaces discussed previously, discharge flue gases at 100F-120F through a plastic (typically PVC) pipe. These furnaces can be vented through a side wall, roof, or to the top of an existing chimney.

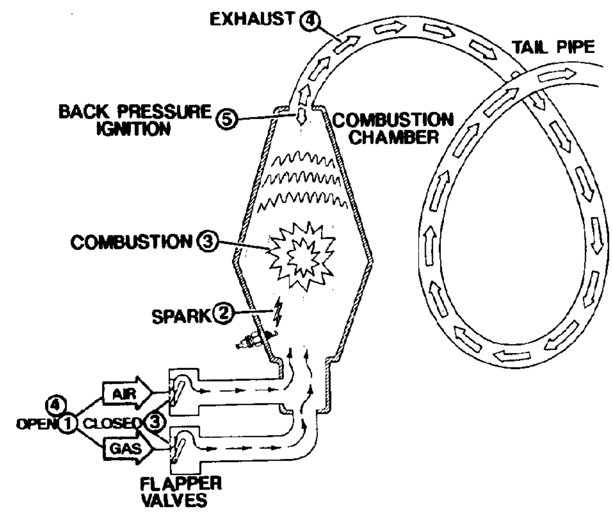


Figure 6-22. Pulse combustion process.

a. Operation.

(1) With thermostat set below room temperature and power to the furnace off, turn manual knob of the gas valve clockwise to the "OFF" position. Wait 5 minutes.

(2) Turn manual knob of gas valve counterclockwise to the "ON" position. Turn power on and set pre-purge for 30 seconds and then ignite.

(3) If the unit does not light on the first attempt, it will attempt up to four more ignitions before locking out.

(4) If lockout occurs, turn thermostat off and then on again.

b. Manual shutoff

(1) Set thermostat to its lowest temperature and disconnect furnace power supply.

(2) Turn manual knob of gas valve to "OFF" position.

6-24. Pulse combustion furnace maintenance.

At the beginning of each heating season, check the furnace as follows:

a. Blower.

(1) Check and clean blower wheel.

(2) Lubricate motor according to the manufacturer's instructions. If no instructions are provided, use the following as a guide:

(a) Motors without oiling ports. These motors are prelubricated and sealed. No further lubrication required.

(b) Direct drive motors with oiling points. These motors are prelubricated for an extended period of operation. For extended bearing life, re-

lubricate with a few drops of SAE No. 10 nondetergent oil once every two years. It may be necessary to remove blower assembly for access to oiling ports.

b. Filters.

(1) Filters must be cleaned or replaced when dirty to assure proper furnace operation.

(2) The washable foam filters supplied with some furnaces can be washed with warm water, dried and sprayed with an adhesive according to the manufacturer's recommendations.

c. Fan and limit control. Check fan and limit controls for proper operation and setting. For settings, refer to manufacturer's setting instructions on each fan.

d. Electrical.

(1) Check all wiring for loose connections.

(2) Check for correct voltage at unit (unit operating).

(3) Check amp draw on blower motor.

e. Intake and exhaust lines. Check plastic intake and exhaust lines and all connections for tightness and make sure there is no blockage. Also check condensate line for free flow during operation.

f. Heat exchangers and burners. Clean with vacuum and/or brush.

6-25. Automatic vent dampers.

The typical building is heated by an oil or gas fired central furnace or boiler. During periods when the indoor temperature drops below the thermostat setting, the heater cycles on and off several times each hour as is required to replace heat lost from the building. Gas furnaces of American Gas Association (AGA) certified design have measured laboratory and field efficiencies of 75 percent at full load steady state operation. During furnace operation, stack energy losses amount to 25 percent of the heating value of the fuel. While the furnace is not operating between heating cycles, natural flue draft will cause air supplied to the furnace to go up the stack. Furnaces which draw combustion and stack dilution air from a heated space require up to 10 percent more fuel to heat the makeup air. The purpose of an automatic vent damper (AVD) is to reduce the losses of this heated air when the furnace is not in operation. No savings are gained while the burner is operating except to the extent that an AVD reduces natural draft when it is open. AVD dampers are classified as to their location and by the type of power used to operate them. A flue damper is one which is installed upstream from the point where dilution air enters the stack. A vent damper is installed downstream of the place where dilution air enters on gas furnaces and downstream of the barometric damper on an oil furnace. Most AVD's on the market today are designed for use as their name implies, in the vent downstream of the draft hood.

a. Thermal dampers. Thermal dampers use hot flue gas to activate their closure mechanism. When the furnace burner is not in operation, bimetallic louvers in a thermal damper close. The design of the louvers when closed offers approximately 10 percent open area, allowing some draft for the pilot light. When the burner is on, the bimetallic louvers bend back toward the walls of the vent providing more draft as the hot combustion products rise in the stack and cause the damper to open. Thermal dampers should only be considered in application to gas burning appliances as oil burners result in temperatures which are excessive. The major advantages of thermal dampers are their relative low cost, simplicity of installation, and ability to operate without need for electrical circuitry.

b. Electrical dampers. Electrically operated vent dampers are available for use with gas and oil burners. Various types of actuation mechanisms are available. In some designs, an electrical motor is used to rotate a metal plate in the flue. In other designs, a lever rotates the shaft which is actuated by a solenoid. All designs of electrical dampers incorporate limit switches which prevent the dampers from closing when the burner is still on. In addition, some designs have a fail safe mechanism that opens the damper in the event of a power failure. Electrical vent dampers have an advantage over thermal dampers in that they are directly controlled by the on/off action of the burner. Closure of the damper is rapid following the burning cycle thereby maximizing the energy savings. Electric dampers do require an external power source and since they are electro-mechanical in nature, are subject to failure of components.

c. Mechanical dampers. Mechanical dampers use a form of mechanical energy to actuate closure of the device. Most such devices are of the gas pressure type. This type is operated by the gas pressure which passes the thermostat controlled main gas valve activating a lever mechanism that opens the damper. A diaphragm actuated valve is used in a return line to the burner to control the gas to the burner. Mechanical dampers have the advantage of not requiring electrical controls. It does require a more complex installation and can, therefore, cost more than other types of dampers.

Section V. GAS FIRED UNIT HEATERS

6-26. General.

Unit heaters are located directly in the space to be heated and basically consist of a radiator and a fan. They differ from fancoil units in that they are generally suspended from the ceiling instead of being placed under windows and they can be direct fired. Certain types, such as steam unit heaters, are supplied with heat from a central heating plant; others, such as gas fired unit heaters, generate the heat within the unit itself. This section covers only gas fired ceiling-suspended units.

6-27. Description.

Gas fired unit heaters (figure 6-23) usually consist of a combustion chamber with atmospheric type gas burners mounted in the bottom. Combustion air enters the combustion chamber through openings in the bottom. A number of radiators or tubes, which act as heat exchangers, extend from the top of the combustion chamber. Across the top of the radiator section is a chamber for collecting the products of combustion and conducting them to a down draft diverter and vent. A propeller type fan, mounted behind the radiator section, forces air through the radiator, heating the air. The fan is usually mounted to the shaft of an electric motor (direct drive), turning at motor speed. Belt driven fans turning at lower speeds are also used. Certain types of unit heaters use a centrifugal blower when higher air velocities are required or when the air must be moved through a duct. The air outlet of a gas fired unit heater usually contains louvers to direct the air stream.

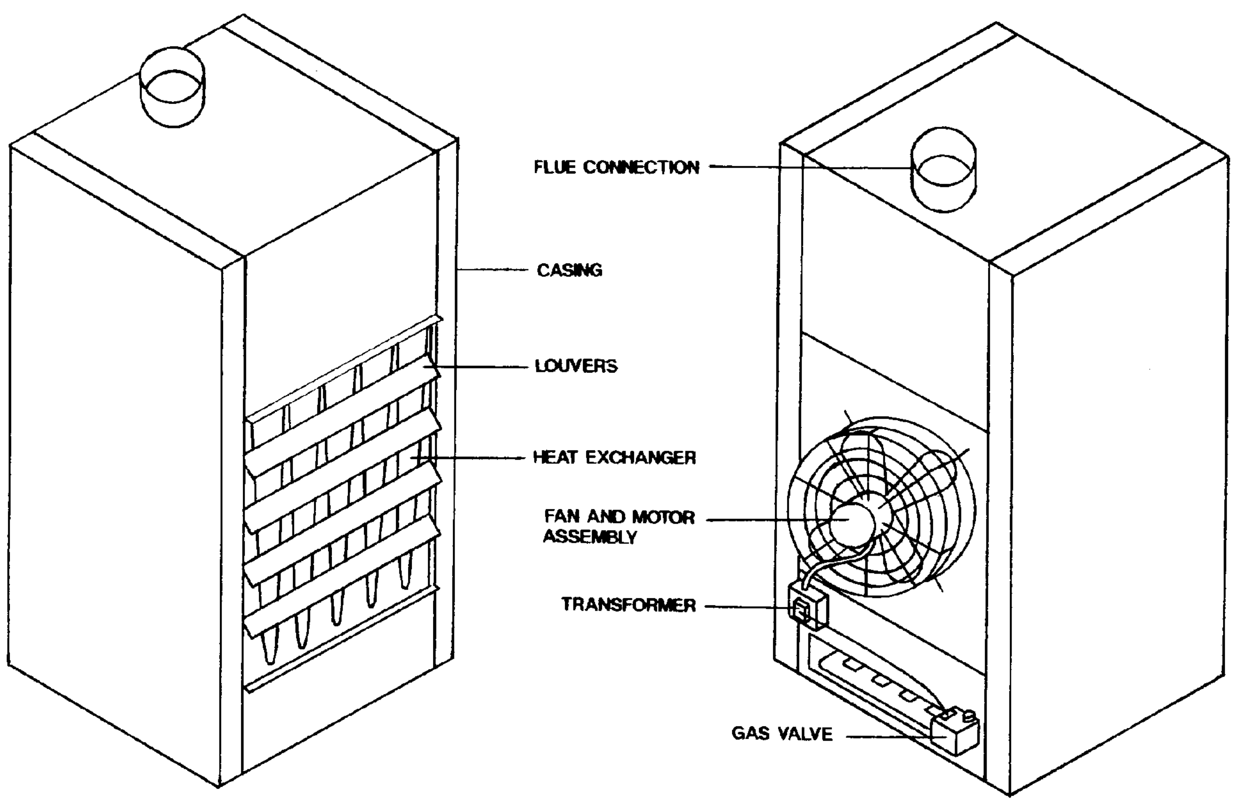


Figure 6-23. Gas fired unit heater.

6-28. Operation.

Gas fired unit heaters have a safety pilot and automatic valve and a suitable control for opening the gas valve only after the fan or blower has started. The operating cycle of the automatic control equipment is as follows:

a. The thermostat makes its electrical contacts, starting the fan or blower, which opens the gas valve, permitting gas to flow to the burner, where it is ignited by the safety pilot.

b. When the space temperature has been raised to a preselected point, the thermostat breaks its electrical contacts, which closes the automatic valve as the speed of the fan (or blower) decreases.

6-29. Installation.

a. Consider the effective length of the heat zone when selecting and locating equipment. Figure 6-24 provides a correlation between the effective length of the heat zone versus discharge air velocity at the unit heater outlet. If the building walls between which the air stream is projected are less than 20 feet apart, the effective length of the heat zone may be lengthened accordingly. The amount of allowable increase depends entirely upon local conditions. With a centrifugal blower, a "throw" of about 50 to 70 feet may be obtained.

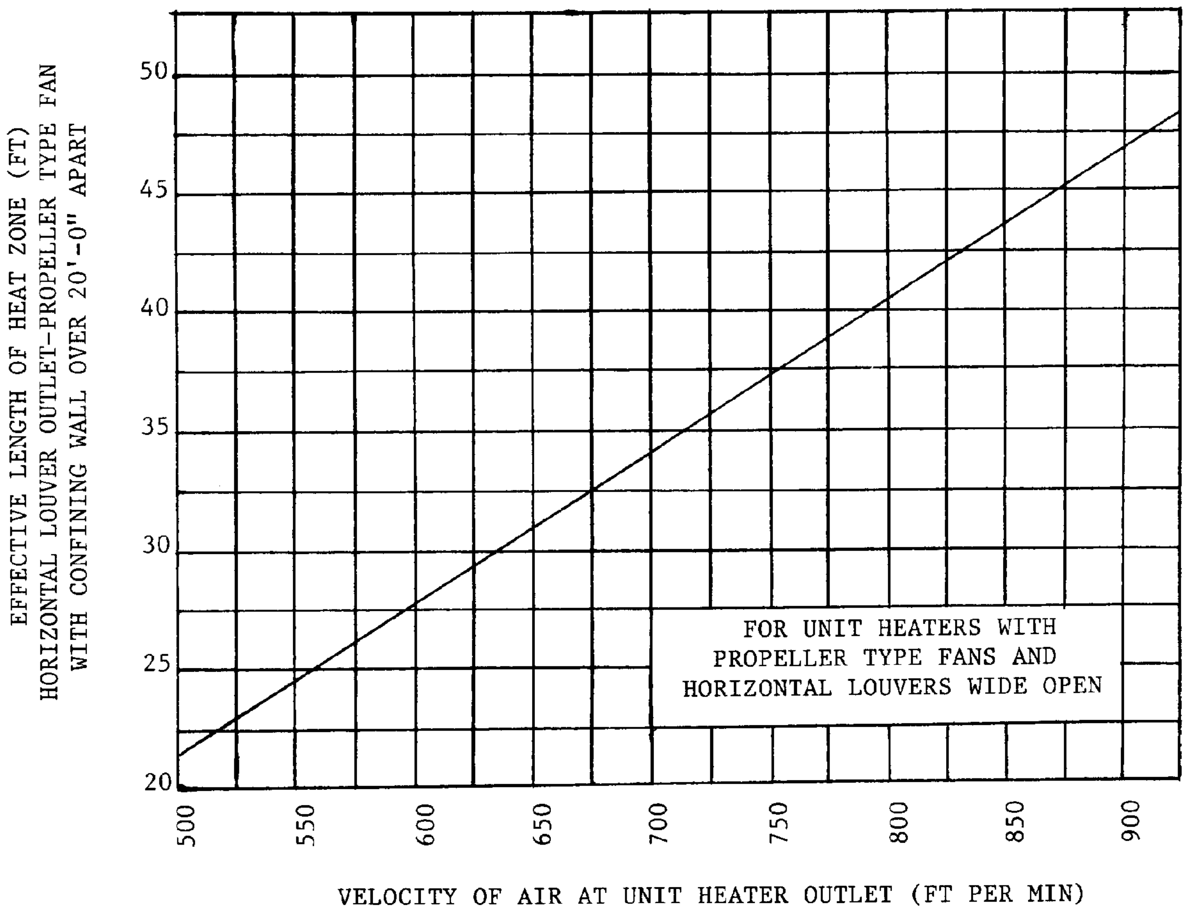


Figure 6-24. Unit heater heat zone length.

b. The ideal position of the unit heater is with the bottom located from 8 to 10 feet above the floor (figure 6-25). If it should be necessary to locate the heaters further above the floor, using a nozzle which points toward the floor helps to obtain a higher velocity. DO NOT INSTALL A UNIT HEATER LESS THAN 18 INCHES FROM A WALL. DO NOT ATTACH COMBUSTIBLE MATERIALS TO HEATERS. Mount the heater in such a fashion that the stream of heated air sweeps the cold walls (unless heat in a specific area is required).

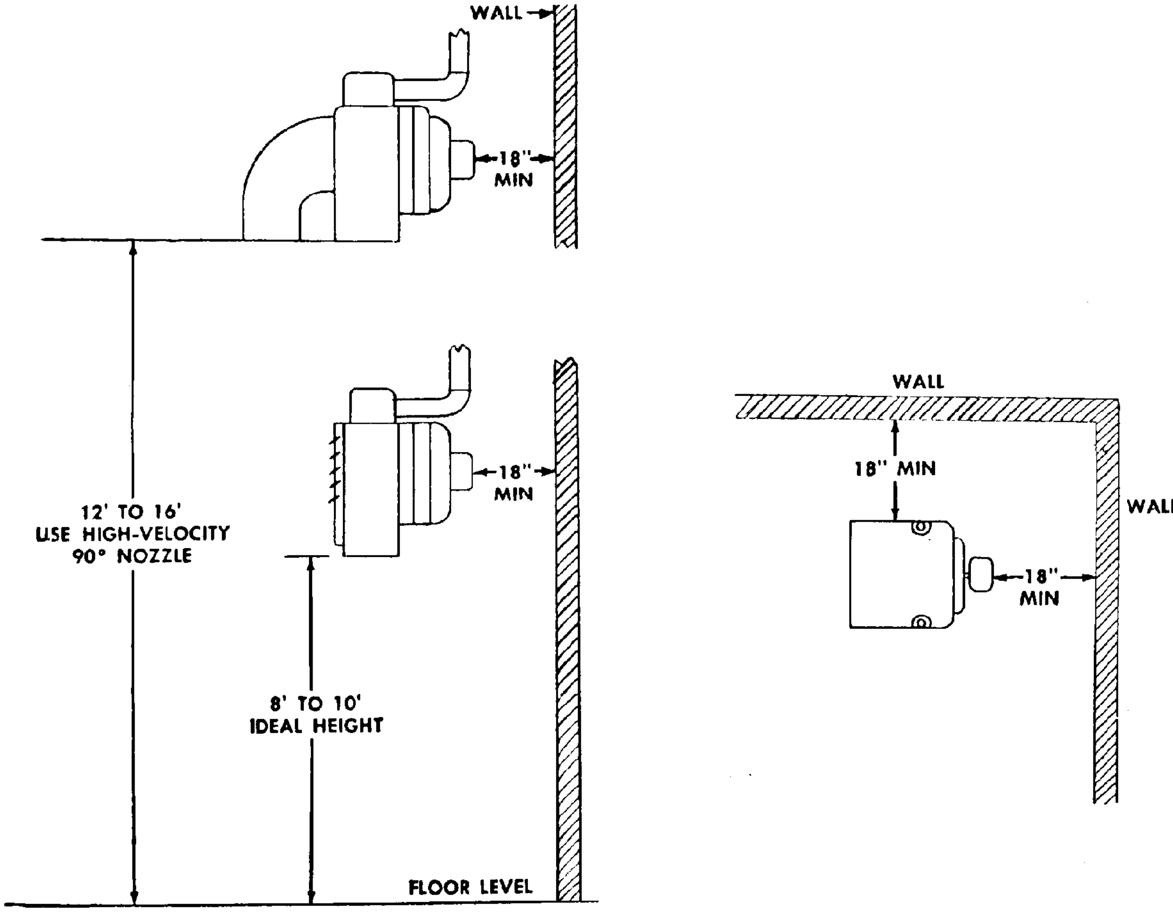


Figure 6-25. Typical unit heater installation.

Section. VI. INFRARED HEATERS

6-30. Gas fired infrared heaters.

Although infrared energy can be produced by burning gas as an open flame, modern gas fired infrared heaters use burning gas to heat a specific radiating surface because heated surfaces tend to be better radiators than open flames. The surfaces are heated by direct flame contact or with combustion gases. Heaters are currently available in four basic types, as follows:

a. Indirect type. Indirect infrared heaters are shown in figure 6-26(a and b). They are indirect in that they are internally fired and have the radiating surface between the hot gases and load. Combustion takes place within the radiating elements, which may be ceramic or metallic, tubes or panels, and which operate with surface temperatures up to 1200 deg F. These units are generally vented and may require deductors (fans), as is the case for the type shown in figure 6-26(b).

b. Porous refractory type. A porous refractory infrared heater is shown in figure 6-26(c). A refractory material is the main element of this type of burner. A combustible gas air mixture enters the enclosure and flows through the refractory material to the exposed face. Combustion occurs quite evenly on the exposed surface, heating it to produce radiant energy to add to that from the flame. Resulting surface temperatures approach 1650F.

c. Direct fired refractory type. A direct fired refractory infrared heater is shown in figure 6-26(d). Impingement of hot gases or flame on an open refractory surface produces the infrared energy emitted by these units. The temperature of the radiating surface ranges from 1650F to 2800F.

d. Catalytic oxidation type. A catalytic oxidation infrared heater is shown in figure 6-26(e). This type heater is somewhat similar to the porous refractory heater in construction, appearance, and operation, but the refractory material is usually glass wool and the radiating surface is a catalyst that causes oxidation to proceed without visible flames.

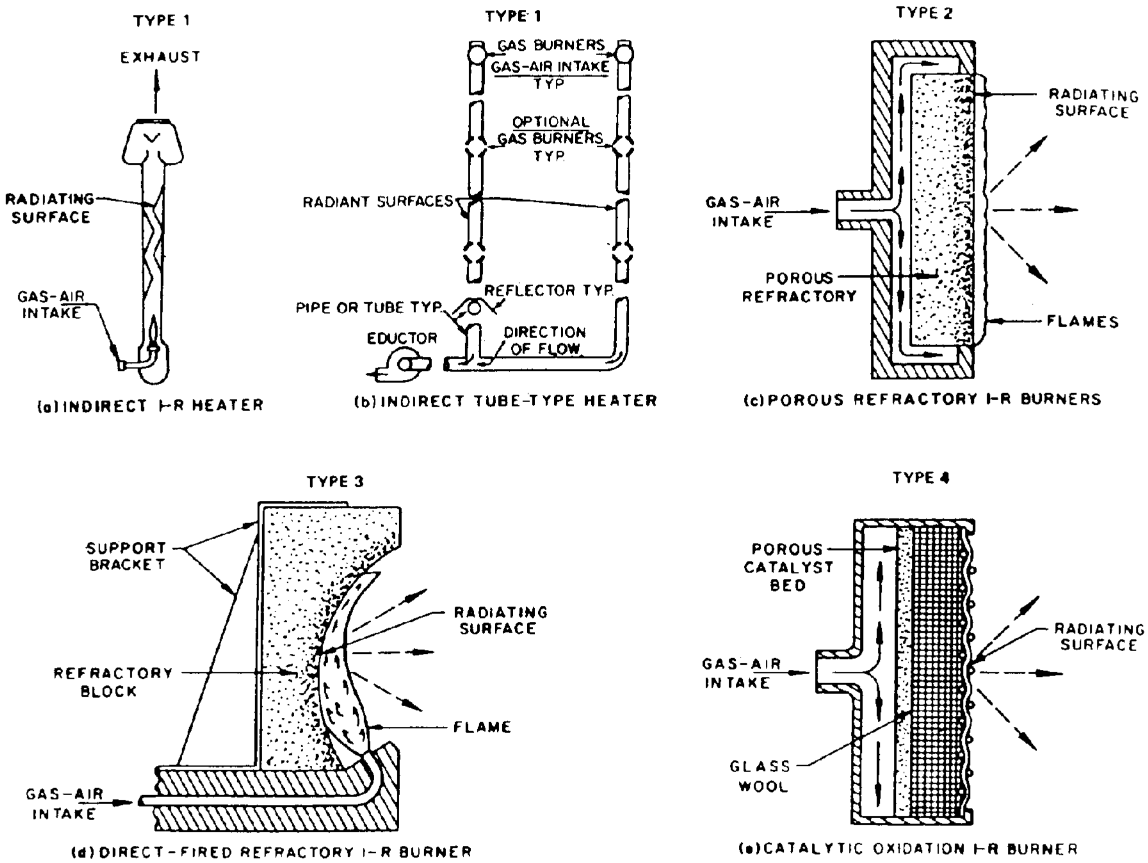


Figure 6-26. Gas fired infrared burners.

6-31. Electric infrared heaters.

Electric infrared heaters use heat produced by current flowing in a high resistance wire or ribbon. There is a wide variety of types; the main difference between them is the way the wire or ribbon is supported and the way the heat is transferred. The following four types are most commonly used:

a. Metal sheath element. The metal sheath element electric infrared heater is shown in figure 6-27(a). The elements are composed of a nickel-chromium heating wire that is embedded in an electrical insulating refractory encased by a metal tube. These elements are the most rugged of the four types and have excellent resistance to thermal shock, vibration, and impact. They can be mounted in any position. At full voltage, the elements attain a sheath surface temperature of from 1200F to 1800F. Higher temperature is obtained by configurations such as a hairpin shape. These units are generally used in a fixture that also contains a reflector which aids in directing radiation to the load. Higher efficiency is obtained if these elements are shielded from wind. When this protection is needed, it is usually provided for by the fixture design.

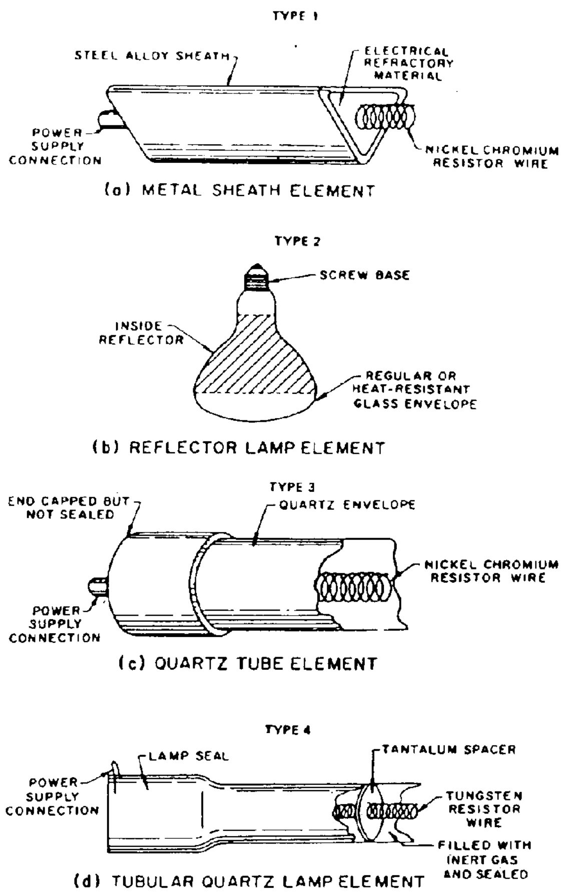


Figure 6-27. Electric infrared heating elements.

b. Reflector lamp type. A reflector lamp infrared heater is shown in figure 6-27(b). This type of heater has a coiled tungsten filament which approximates a point source radiator. The filament is enclosed in a heat-resistant, clear, frosted, or red glass envelope which is partially silvered inside to form an efficient reflector. Common units may be screwed into an ordinary 120 volt light socket.

c. Quartz tube type. A quartz tube infrared heater is shown in figure 6-27(c). This unit has a coiled nickel-chromium wire lying unsupported within an unevacuated fused quartz tube, which is capped (not sealed) by porcelain or metal terminal blocks. These units are easily damaged by impact and vibration, but stand up well to thermal shock and splashing. They must be mounted in a horizontal position to minimize problems of coil sag and are usually used in a fixture that also contains a reflector which aids in directing radiation to the load. Normal operating temperature ranges from 1300F to 1800F for the coil and about 1200F for the tube.

d. Quartz lamp type. A quartz lamp infrared heater is shown in figure 6-27(d). A typical unit consists of 0.38 inch diameter fused quartz tube containing an inert gas and a coiled tungsten filament that is held in a straight line and away from the tube by tantalum spaces. Filament ends are embedded in the envelope end sealing material. Quartz lamps must be mounted horizontally, or nearly so, in order to minimize filament sag and overheating of sealed ends. At normal design voltages, quartz lamp filaments operate at about 4050F and the envelope at about 110F.

6-32. Oil fired infrared beaters.

Oil fired infrared heaters are similar to gas fired indirect type units. Oil fired units are vented.

6-33. Precautions.

Observe the following precautions in the application of infrared heaters:

a. All infrared heaters discussed here have high surface temperatures when they are operating and, therefore, should not be used where the atmosphere contains ignitable dust, gases, or vapors in hazardous concentrations.

b. Manufacturer's recommendations for clearance between a fixture and combustible material should be followed. If storage of combustible material without adequate clearance between it and a fixture is likely or possible, warning notices defining proper clearances should be permanently posted near the fixture.

c. Manufacturer's recommendations for clearance between a fixture and personnel should be followed in order to prevent personnel stress from local overheating.

d. High intensity infrared fixtures should not be used if the atmosphere may contain gases, vapors, or dust that decompose to hazardous or toxic materials in the presence of high temperature and air. For example, infrared units should not be used in an area where there is a degreasing operation which uses trichloroethylene, which when heated, forms phosgene, a toxic compound, and hydrogen chloride, a corrosive compound.

e. Humidity control is necessary for areas with unvented gas fired infrared units because water formed by combustion will increase humidity. Sufficient ventilation, direct venting, or installation of insulation for cold surfaces are means that may be used.

f. When combustion type infrared heaters are used, adequate makeup air must be provided to replace the air used in combustion, regardless of whether or not units are direct vented.

g. If unvented combustion type infrared heaters are used, adequate ventilation must be provided to assure that products of combustion in the air in the space are held to an acceptable level.

h. Personnel who are to be maintained at a comfort level by use of infrared heating equipment should be protected from substantial wind or drafts. Usually, suitable wind shields that prevent windchill are more effective than increasing radiation to compensate for it.

6-34. Maintenance.

The manufacturer's recommendations should always be followed. Electric infrared systems require little care beyond keeping the reflectors clean. Quartz and glass elements must be handled carefully because they are fragile, and fingerprints must be removed (preferably with alcohol) in order to prevent etching at operating temperature, which in turn will cause early failure. Gas fired and oil fired infrared heaters require periodic cleaning to remove dust, dirt, and soot. Reflecting surfaces, in particular, must be kept clean in order to be efficient. An annual cleaning of heat exchangers, radiating surfaces, burners, and reflectors should be performed with a cleaner that does not leave a film on aluminum surfaces. Both main and pilot air ports of gas fired units should be kept free of lint and dust. The nozzle draft tubes, and end cones of burners of oil fired units have been designed to operate in a particular combustion chamber and, when necessary, should always be replaced with an exact duplicate.

Section VII. OPERATING AND MAINTENANCE PROCEDURES

6-35. General.

Most warm air systems at Army installations are of the forced air type; therefore, operating and maintenance procedures described herein refer to forced warm air systems and equipment.

6-36. Blower and motor maintenance.

The blower assembly includes the blower, motor, motor base, V-belt or direct drive, and the complete housing. Following is a description of normal operating and maintenance procedures for V-belt driven blower and direct drive blower assemblies.

a. V-belt driven blower.

(1) *Blower speed adjustment.* The motor pulley is usually adjustable for a wide range of speeds. Adjust the speed of the blower to deliver the volume of air called for in the specifications. After this has been done and a change of blower speed is required, make the change by adjusting the motor pulley, then resetting the belt tension. A simple way to determine the proper volume of air is to hold a handkerchief at the top of the warm air outlet and let the moving air raise it. Velocity should be such that the handkerchief is blown almost horizontal. Every installation having a substantial number of warm air furnaces should have a direct reading instrument for determining actual air velocities. To adjust the motor pulley, loosen the setscrew (figure 6-28) and separate the two pulley faces to decrease blower speed. Bring the faces closer together to increase speed. When locking the pulley adjustment with the setscrew, be sure to force the setscrew down on the flat surface of the pulley shaft and not on the threads.

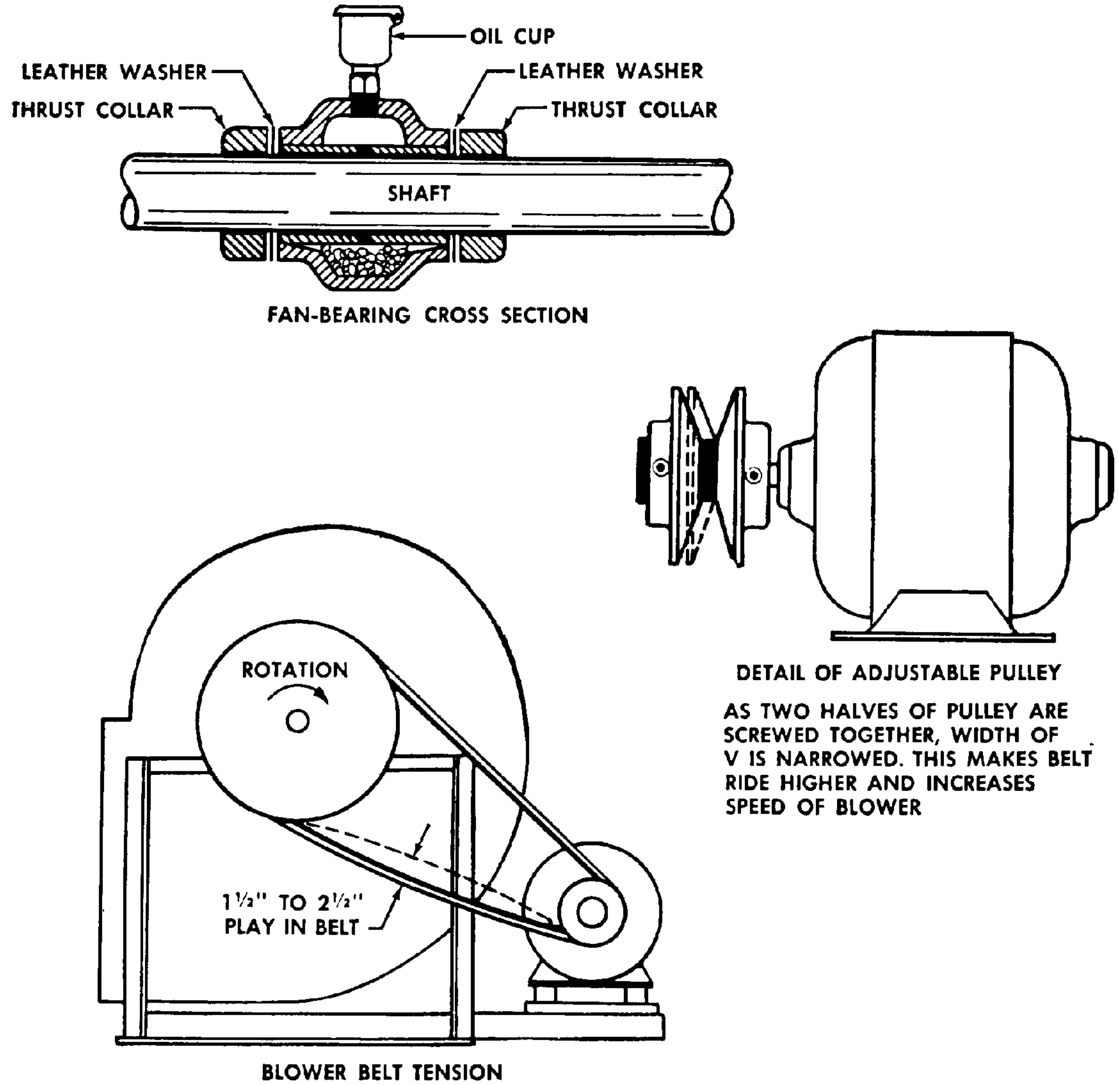


Figure 6–28. Fan bearing, pulley, and belt adjustments.

(2) *Belt tension adjustment.* To adjust belt tension, slide the motor on its base. Every motor has an adjustment for this purpose. Unless a manufacturer specifically recommends a tighter adjustment, leave from 1½ to 2½ inches up and down slack in the middle of the belt, depending on its length. (See figure 6-28.) If a V-belt is adjusted too tight it will wear rapidly and seriously overload the motor. If it is too loose, it will slip.

(3) *Alignment.* Check motor pulley and blower alignment on each installation, using a straight edge. The motor shaft is usually long enough to allow for this adjustment. However, if the alignment adjustment cannot be made by this method, move the motor into proper position.

(4) *Blower bearing adjustment.* Most blowers have bearings that are self-aligning. Some, however, have bearings that are held in alignment by bolts that anchor the bearings to the blower. For bearings of this type, check alignment; if bearings are binding, loosen bolts, bring into alignment, and retighten bolts.

(5) *Thrust collar adjustment.* Thrust collars are locked to the shaft on each side of one of the blower bearings. These collars keep the blower wheel in alignment and, when properly set, eliminate end play. If a thumping noise occurs in the blower, there is excessive end play. This noise may be eliminated by setting the thrust collar closer. Exercise care to set collars as closely as possible without binding. With either type of bearing, remove the belt and rotate the blower wheel to be sure it moves freely.

(6) *Lubrication of blower and motor.* Oil the motor and blower bearings when the unit is placed in service and periodically during the heating season according to manufacturer's instructions. Use the proper grade oil for blower and motor bearings in accordance with applicable technical manuals and manufacturer's instructions.

b. Direct drive blower. Figure 6-29 shows a typical arrangement of a blower with direct drive.

(1) *Blower speed adjustment.* In alternating current applications, the blower speed is limited to the available motor speed. For example, a two speed motor will provide two blower speeds. In direct current applications, motor controllers are installed to provide a wide range of blower speed variation.

(2) *Other maintenance.* Procedures for motor and blower alignment and lubrication, and adjustment of blower bearings and thrust collars are the same as previously described for belt driven blowers.

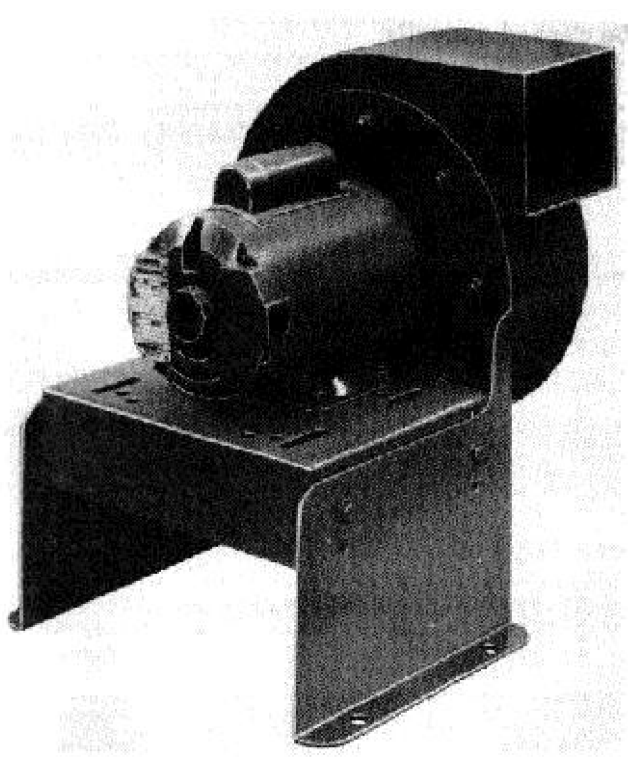


Figure 6-29. Direct drive blower.

c. Heat exchangers and burners. Clean with a vacuum and/or brush.

6-37. Air filter maintenance.

a. Replaceable type filters. Dirty filters impede air circulation, regardless of blower speed. If little or no air passes over the furnace, the building will be insufficiently heated and the furnace will overheat, which may result in serious damage. Inspect filters often. If filters are dirty or air circulation is obviously impaired, replace filters.

b. Permanent washable type filters. For permanent washable type filters, follow carefully cleaning directions supplied by filter manufacturer or consult applicable technical manuals. Washable filters should be renewed with adhesive spray following cleaning to enable them to pick up dust effectively.

c. Electronic air cleaners. This type unit employs the principle of electrostatic precipitation. Particles in the air entering the unit become positively charged and are attracted by the negatively charged collector plates and held there. Periodic washing of collector plates is required. Application of adhesive coating on a prefilter may be required. Follow carefully manufacturers' instructions for proper maintenance of these units.

d. Activated charcoal filters. These filters are installed in the return air plenum of warm air furnaces or in self-contained purifying units consisting of one or more activated charcoal filters, blower, and housing. Disposable filters should be replaced periodically per manufacturers' recommendations. Manufacturer's instructions should be followed for the maintenance of permanent filters.

6-38. Humidifiers.

a. Pan type humidifiers. Most humidifiers used in Army warm air systems are the pan type with a float to regulate the water level (figure 6-30). Because of the high temperature to which the float valve is subjected, it frequently sticks in an open or closed position. To release the valve, move the float ball up and down to allow water pressure to clean the dirt or other accumulation from the seat. Frequent jiggling of this float control will prevent sticking. If water is comparatively free of solids, the humidifier float seldom requires service. If the water condition is bad however, considerable difficulty may arise. It is of prime importance to check the installation of the pan to see that it does not overflow on the combustion chamber or radiator of the furnace. Pan type humidifiers must be regularly cleaned to prevent accumulation of minerals precipitating from the water. Chemicals specifically made for use in humidifiers can be added to the pan to keep minerals in suspension until they can be flushed out. Biocides are also available which can be added to the pan to prevent algae and bacteriological growth. At the end of each heating season, turn off the water supply, clean the humidifier and leave it empty until the next heating season.

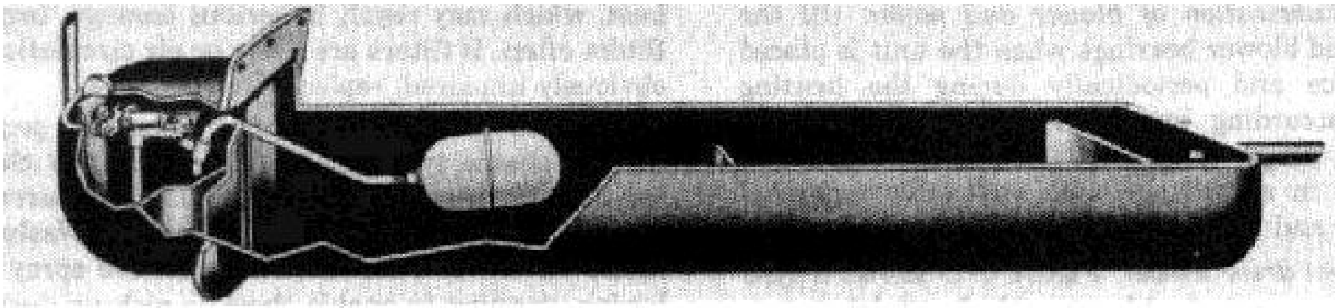


Figure 6-30. Pan type humidifier.

b. Other humidifiers. Other types of humidifiers used on Army installations are the centrifugal atomizer, steam spray, and steam jacketed manifold types. With the centrifugal atomizer type (figure 6-31) a high speed rotating disc imparts motion to a fine stream of water directed against its center. Stationary blades further atomize the water and direct it away from the disc and housing. With the steam spray humidifier (figure 6-32) dry mineral free steam is produced and discharged directly into the atmosphere. With the steam jacketed manifold humidifier (figure 6-33) steam is dried and purifled by passing it through a separator, superheating it, and then distributing it through a steam jacket manifold. Steam that has been treated with amine type chemicals should not be used for direct humidification. These chemicals are toxic and are carried over with steam. Steam is normally free from minerals and thus mineral accumulation on steam humidifiers is not a problem. It is good practice however, to clean this type of humidifier each year to prevent nozzles from clogging. Centrifugal humidifiers and surrounding ductwork should also be cleaned annually.

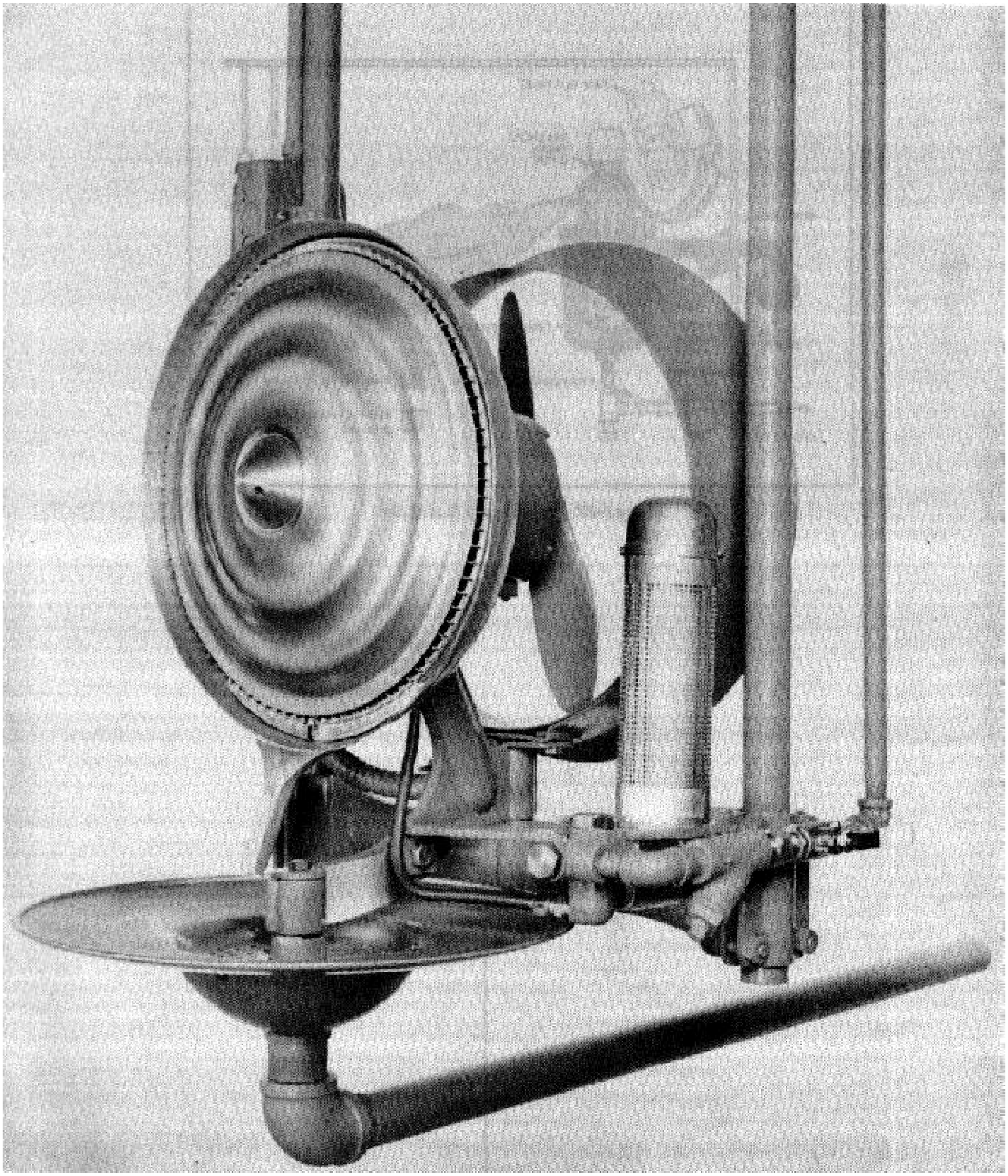


Figure 6-31. Centrifugal atomizer humidifier.

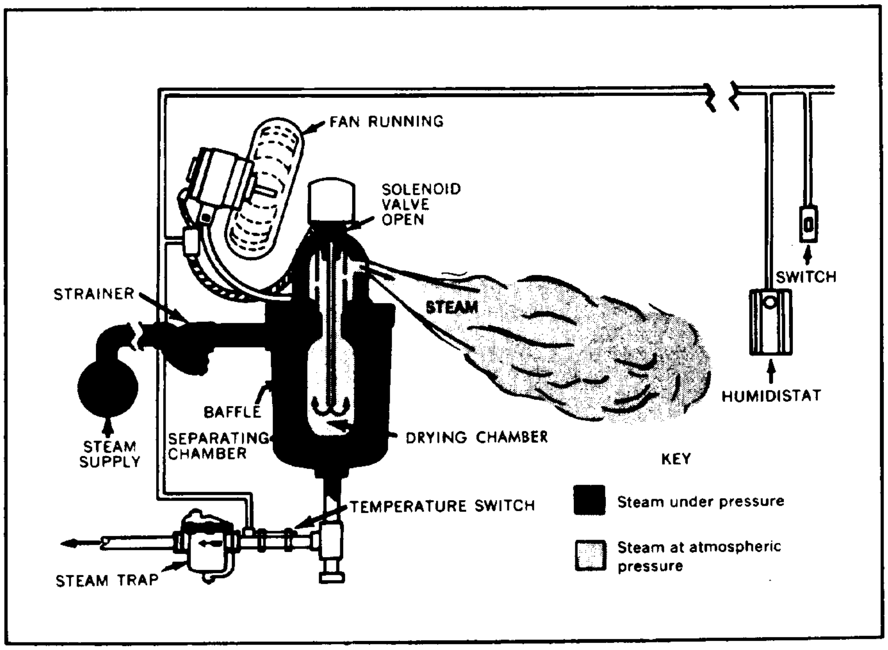


Figure 6-32. Steam spray humidifier.

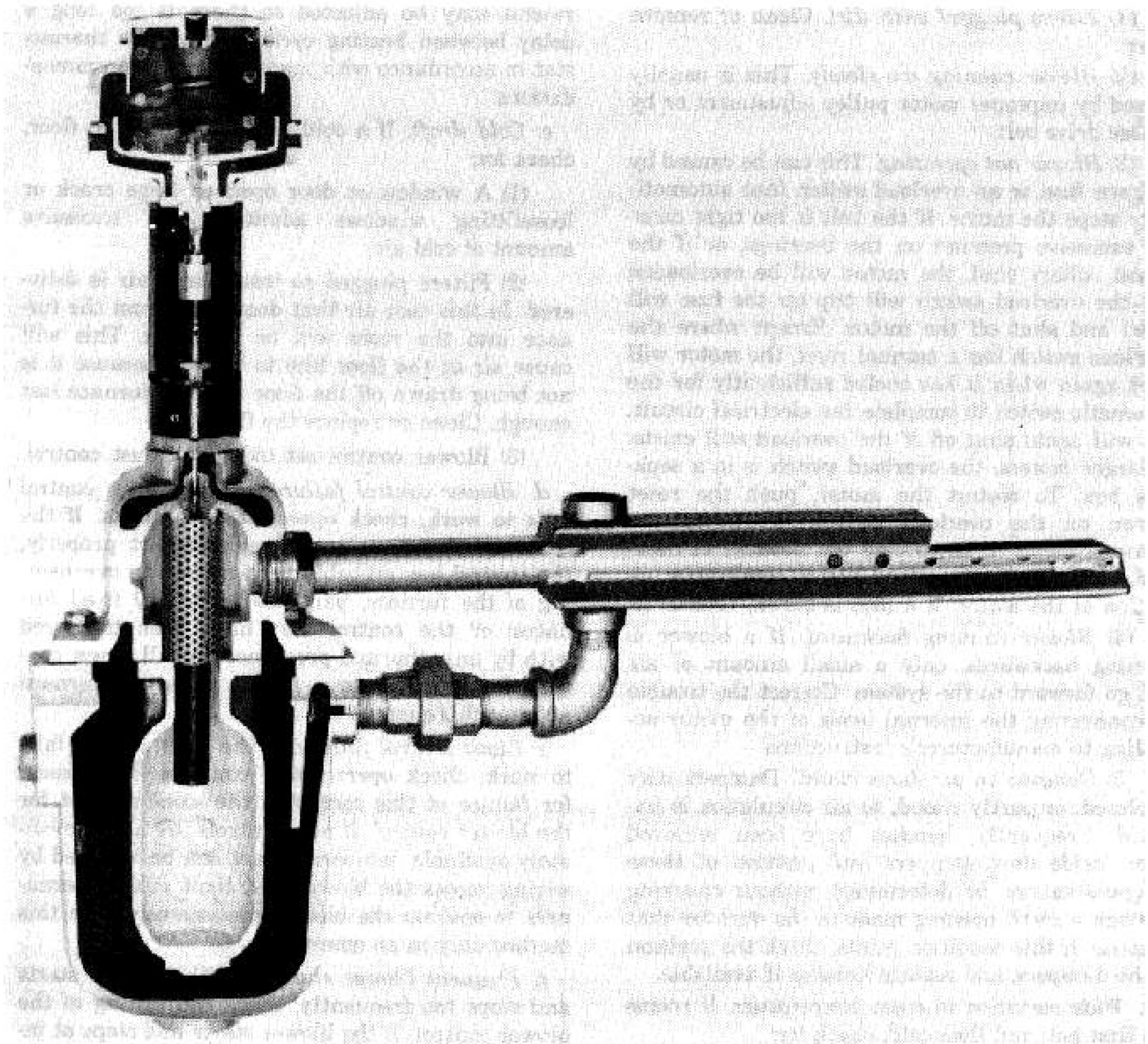


Figure 6-33. Steam jacketed manifold humidifier.

6-39. Blower and limit controls.

A combination blower and limit control is generally installed in the top of the furnace casing in an opening provided by the manufacturer. It is installed 10 to 18 inches above the top of the combustion chamber and in a location that is easily accessible for inspection and adjustment.

a. Blower control adjustment. Set blower control, or furnacestat, to stop blower between 90F and 100F in the plenum chamber. Adjust the control to start blower at 115F for gas or oil, and 125F for coal. The blower should run almost continuously when the outside temperature is 40F or below. The more continuously the blower runs, the better the building will be heated, particularly in cold weather. A slightly higher temperature setting may be used in cold climates, or where a long duct is installed, or to meet some other local condition.

b. Limit control adjustment. Set the limit control to turn off the fire at 175F in milder climates and 200F in colder climates, and to turn it back on at 155F in milder climates and 170F in colder climates. Never set the limit control any higher than necessary to keep the building at the proper temperature.

6-40. Troubleshooting.

Common operating difficulties and methods of correcting them are outlined below.

a. Insufficient heat. If not enough heat is supplied, check for:

(1) *Filters plugged with dirt.* Clean or remove filter.

(2) *Blower running too slowly.* This is usually caused by improper motor pulley adjustment or by a loose drive belt.

(3) *Blower not operating.* This can be caused by a blown fuse or an overload switch that automatically stops the motor. If the belt is too tight causing excessive pressure on the bearings, or if the thrust collars bind, the motor will be overloaded and the overload switch will trip (or the fuse will blow) and shut off the motor. Except where the overload switch has a manual reset, the motor will start again when it has cooled sufficiently for the automatic switch to complete the electrical circuit, but will again shut off if the overload still exists. In larger motors, the overload switch is in a separate box. To restart the motor, push the reset button on the overload switch. Whenever the motor is found to be cutting out because of overload, eliminate the overload before continuing operation of the motor. If a fuse is blown, replace it.

(4) *Blower running backward.* If a blower is running backwards, only a small amount of air will go forward to the system. Correct the trouble by connecting the internal leads of the motor according to manufacturer's instructions.

(5) *Dampers in air ducts closed.* Dampers may be closed, or partly closed, so air circulation is impeded. Frequently, handles have been removed from inside duct dampers and position of these dampers cannot be determined without checking through a small opening made in the duct for that purpose. If this condition exists, check the position of the dampers, and replace handles if available.

b. Wide variation in room temperature. If rooms are first hot, and then cold, check for:

(1) *Blower control set too high.* If the blower control setting is too high, the blower will not start until the furnace is very hot and a surplus of heat is then blown into the building. Set blower control down in accordance with recommendations for blower control settings. To test for this condition, turn on the manual switch controlling the blower and permit it to operate continuously. If this relieves the condition, the blower control is set too high.

(2) *Room thermostat out of adjustment.* The throttling range or anticipator setting on the thermostat may be adjusted so there is too long a delay between heating cycles. Adjust the thermostat in accordance with manufacturer's recommendations.

c. Cold draft. If a cold draft is noticed on floor, check for:

(1) A window or door open or large crack or loosefitting windows admitting an excessive amount of cold air.

(2) Filters plugged so insufficient air is delivered. In this case air that does come from the furnace into the room will be very hot. This will cause air at the floor line to be cold because it is not being drawn off the floor into the furnace fast enough. Clean or replace the filters.

(3) Blower control set too low; adjust control.

d. Blower control failure. If the blower control fails to work, check operation of contacts. If the control fails to make or break contact properly, the control has probably been ruined by overheating of the furnace, particularly in coal fired furnaces; or the control may have been tampered with by unauthorized personnel. Install a new control. Do not operate a forced warm air furnace without this control.

e. Limit control failure. If the limit control fails to work, check operation of contacts. The reason for failure of this control is the same as that for the blower control. If new controls are not immediately available, temporary heat can be obtained by wiring across the blower and limit control terminals to operate the blower continuously. Use this method only in an emergency.

f. Frequent blower shutoff If the blower starts and stops too frequently, check the setting of the blower control. If the blower starts and stops at intervals of 2 or 3 minutes, motor life will be shortened. This also overheats the overload switch in the blower control. Increase the differential between starting and stopping temperatures on blower control by 10F. This will usually overcome the difficulty.

g. High outlet temperature. Outlet temperature should not exceed 160F for an extended period of time. The most frequent cause of high outlet temperature is insufficient airflow. This can be caused by blocked filters, too low a fan speed, or restricted ductwork.

Section VIII. ENERGY CONSERVATION

6-41. Space temperature setback.

Energy expended to heat buildings to comfort conditions when they are unoccupied is wasted. Save energy by setting back the temperature level at these times. The savings which can result vary with the length of time and the number of degrees that temperatures are set back. The percentage savings will be greater in warmer climates, but the gross energy saved will be greater in cold climates. In areas where it is not necessary to maintain high temperatures during occupied periods, i.e. corridors and lobbies, maintain even lower temperatures than for the other spaces. Implement setback by resetting thermostats manually (if automatic setback control has not been installed), or adjusting controls to suggested temperatures (if clock, day-nite, or other automatic reset controls are available). Climate, type of system, and building construction will determine the length of the startup period required to attain daytime temperature levels. Experiment to decide upon the optimal setback temperature and startup time for any particular building. If, in extremely cold weather, experience indicates that the heating system does not raise the temperature sufficiently by the time the building opens for the day, set temperatures back to a level higher than those recommended here for those periods of time only. So called “smart thermostats” and computerized Energy Monitoring and Control Systems (EMCS) automatically calculate the most effective time to end setback.

6-42. Maintenance of duct insulation.

a. Warm air ducts are commonly installed without insulation and are typically routed from the equipment room through unoccupied spaces, shafts, and ceiling voids where their heat loss is unproductive in meeting the occupied space heating load. Although the temperature difference between duct and ambient temperature is relatively small, heat loss in long duct runs can be significant.

b. Of equal importance is the temperature drop of supply air that accompanies heat loss. In long duct runs serving many rooms on one zone, this will result in the last room having a lower supply air temperature than the first. The tendency in this case is to heat the last room to comfort conditions resulting in overheating in each preceding room.

c. Warm air ducts may be insulated with rigid fibrous material stuck on or fixed with special clips or bands. They may also be insulated with flexible mats clipped or wired on (this is particularly applicable for round or oval ducts). Ducts may also be insulated with spray-on foam or fibrous material as used for insulating undersides of roofs. It is worth considering insulating roofs and ducts as one contract.

d. Insulation applied to ducts supplying only warm air need not be vapor sealed. Insulation applied to ducts supplying warm air in winter and cold air in summer must be vapor sealed to prevent condensation forming within the insulation.